# FINAL DESIGN REPORT
# FOR
# UNDERGROUND WATER QUALITY DETENTION BASIN
# AT
# PALOMAR AIRPORT

**Job Number 14804-E**
**October 10, 2006**

RICK ENGINEERING COMPANY

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**Job Number 14804-E**


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**October 10, 2006**

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**Map Pockets:**

Map Pocket 1: Watershed Tributary to Underground Water Quality Basin for McClellan-Palomar Airport

Map Pocket 2: Copy of Plan Sheets 2 and 4 for the Underground Detention Basin at McClellan-Palomar Airport

**References:**


1 – Quality Assurance Project Plan (QAPP) for McClellan-Palomar Airport Conveyance Restoration and Water Quality Treatment Facility. Photo Documentation, Water Quality, and Sediment Quality Monitoring. Grant Agreement Number 04-201-559-0. October 2005.

2 - Sampling and Analysis Plan (SAP) for Proposition 13 Grant Agreement No. 04-201-559-0, San Diego Region, McClellan-Palomar Airport Conveyance Restoration and Water Quality Treatment Facility. Photo Documentation, Water Quality, and Sediment Quality Monitoring. October 2005.

3 - Plans for Construction of Underground Detention Basin at McClellan-Palomar Airport (Record Drawings dated 04/28/06)

# 1.0 INTRODUCTION

## 1.1 PROJECT DESCRIPTION

The County of San Diego Department of Public Works has received a grant agreement from the State Water Resources Control Board (State of California) that is identified as Agreement No. 04-201-559-0. The grant agreement calls for the removal of concrete channelization and creation of an underground detention basin for the capture of dry and weather flows. This report has been prepared to summarize and provide the back-up data regarding hydraulics, hydrology, existing facility data, design criteria, specific design requirements, design constraints, assumptions, alternatives, quantity and cost estimate support, and all engineering calculations and analyses in regards to the water quality facility.

It is important to note that a larger project is to be constructed concurrent with this project, at the same location of McClellan-Palomar Airport. The other project has been funded by the Federal Aviation Administration (FAA) and proposes to provide a new taxiway and parking area for small planes (per the Master Plan Layout for McClellan-Palomar Airport). The engineer of work for the FAA project is Wadell Engineering, with PDC Consultants offering additional services (such as surveying) on behalf of Wadell Engineering. The two projects are to be constructed by the same contractor, with the FAA project known as Schedule A, and the underground water quality facility known as Schedule B.

## 1.2 PROJECT LOCATION

The underground water quality basin is to be constructed on the northern side of the existing McClellan-Palomar Airport property, in the City of Carlsbad, in the State of California. The airport is located adjacent to and north of Palomar Airport Road and west of El Camino Real (Thomas Bros. page 1127, D-2).

A Vicinity Map for the project location has been provided as Appendix A. A copy of the basin layout is also shown in Appendix H of this report, and copies of Plan Sheets 2 and 4 are included for reference in Map Pocket 2 (these sheets depict specific details, the plan view, and the profile view of the facility).

## 1.3 TOPOGRAPHY AND LAND USE

The project area is characterized as downward sloping away from the existing airport runway, and comprised of mostly natural landscape with a concrete conveyance channel directing runoff towards an existing Type 'F' catch basin at the north-central boundary of the overall airport boundary. On the northern side of the property boundary are existing buildings and an underground storm drain system which conveys runoff that leaves the airport at the existing catch basin. An existing San Diego Gas & Electric (SDGE) easement parallels the northern property boundary with a large gas line located within.

The proposed FAA project will provide a large retaining wall along the edge of the SDGE easement that will extend vertically in order for the existing slope to be filled-in for the FAA taxi-way and plane parking area. As a result, the land use at the completion of this project will be nearly 100% impervious.

The County of San Diego provided the topography that was used during the design, and additional field survey data (provided to Rick Engineering Company by PDC Consultants and Wadell Engineering) has been used to supplement the topography during design of the basin.

## 1.4 DRAINAGE CHARACTERISTICS

The tributary drainage area that will flow through the proposed underground water quality treatment facility is fully comprised of runoff from the airport. Several field visits were performed during the early stage of design, with one specifically intended to summarize the existing drainage patterns and boundary that contributes to the project site. The site visit was performed in the presence of the airport manager in order to utilize his on-site knowledge of drainage facilities. As a result of the visit, the existing storm drain facilities and outlets for roof-top runoff from the existing buildings were observed and are summarized on the drainage study map, included in Map Pocket 1 of this report.

The drainage area can be described as having two major sub-basins. The separation of these two sub-basins coincides with the center of the runway, running east to west. The northern half is collected by the on-site storm drain system that is to be built in conjunction with the FAA project. The southern sub-basin collects the southern-half of the runway, most of the frontage area along the existing buildings, and a portion of rooftop runoff from those same buildings. Runoff from these areas are collected via existing storm drain inlets and pipes that all connect at an existing low-point (sump), located at the south-central edge of the existing runway.

The existing sump where the southern sub-basin drains to is then conveyed under the existing runway via an existing 30" CMP that has been slip-lined and is equivalent to a 19" PVC. This storm drain runs north to an existing manhole located in the existing grass area just north of the existing runway. From there, the existing storm drain increases to a 36-inch RCP which continues to flow north where it eventually ties-in to the existing Type 'F' catch basin mentioned earlier in this report. The proposed project will provide the water quality facility between the existing manhole (at the northern edge of the existing runway) and the existing catch basin at the northern edge of the property boundary.

The project will abandon the existing storm drain system through this location, and will construct a new 36-inch RCP mainline between these two locations, with an additional off-line system that will collect low-flow storm events and convey this runoff through the proposed water quality facility prior to discharging back into the new mainline, immediately upstream of the existing Type 'F' catch basin.. The proposed storm drain layout and underground water quality treatment facility is shown in Appendix H, as well as on plan sheet 2, included in Map Pocket 2 of this report.

The following portions of this report address the hydrology, water quality treatment, design constraints and basin configuration, hydraulics, and other design parameters in further detail.

# 2.0 HYDROLOGY

## 2.1 HYDROLOGIC CHARACTERISTICS

The hydrologic characteristics for the project have been analyzed using a modified rational method computer program (AES 2003). The analysis has been completed following the criteria specified in the County of San Diego Hydrology Manual – June 2003. The drainage study map, located in Map Pocket 1, identifies the drainage boundaries, node numbers, and areas used to prepare the hydrologic analysis for a 100-year peak storm event. The analysis has been prepared for the ultimate land use, per the Master Plan layout for the airport; therefore, the runoff coefficient ('C' value) is 0.90. The following table summarizes the results:

**Table 2.1**
**Summary of Hydrologic Characteristics for**
**Underground Water Quality Detention Basin at McClellan-Palomar Airport**

| | At Existing Sump on South Side of Runway (Node 110) | At Proposed Water Quality Detention Basin and Project Outfall (Node 120 and 130) |
|---|---|---|
| 100-Year Peak Runoff ($Q_{100}$), cfs: | 186.6 | 388.1 |
| Tributary Drainage Area (A), acres: | 42.9 | 89.9 |
| Time of Concentration ($T_C$), min: | 9.4 | 9.5 |
| Runoff Coefficient: | 0.90 | 0.90 |

Note(s) - Refer to the Drainage Study Map, provided in Map Pocket 1, for specific location of each Node listed above.

A copy of the AES Modified Rational Method computer program output has been provided in Appendix B of this report.

# 3.0 WATER QUALITY TREATMENT

## 3.1 WATER QUALITY TREATMENT CHARACTERISTICS/REQUIREMENTS

The water quality treatment characteristics that are desired per the numerical sizing criteria, established within the County of San Diego SUSMP, have been determined per flow-based and volume-based criteria. A flow-based criterion requires a treatment flowrate based on an intensity of 0.2 in/hr, while the volume-based criteria require treating approximately 0.65 inches. The table below summarizes the water quality treatment flowrate and volume that would be required to meet the numerical sizing criteria (per the SUSMP), as well as the water quality treatment that is actually proposed for the project:

**Table 3.1**

**Summary of Water Quality Treatment Characteristics for Underground Water Quality Detention Basin at McClellan-Palomar Airport**

| | Desirable per SUSMP (numerical sizing criteria) | Provided by Project |
|---|---|---|
| Water Quality Treatment Flowrate ($Q_T$), cfs: | 16.2 cfs | 20.0 cfs |
| Water Quality Treatment Volume ($WQ_V$), acre-ft: | 4.4 ac-ft | 0.15 ac-ft |

Copies of the numerical sizing criteria calculations for the project are provided in Appendix C of this report. Backup information for the water quality treatment that is provided by the project BMPs are provided in Appendices D and E, as discussed later within this report.

Based on the results of the water quality treatment calculations, several alternative post-construction BMP devices were considered. The initial goal was to size an underground BMP that would provide volume-based treatment as the sole-treatment method. However, after comparing several volume-based BMPs, it became evident that the size of such a structure was not feasible for this project based on the site conditions and fiscal resources. It was determined that a combination of flow-based and volume-based treatment would be appropriate to meet the goals of the grant agreement and provide water quality treatment of the airport runoff. The various alternatives that were considered prior to proceeding with the final design option are discussed in further detail in the following section.

## 3.2 ALTERNATIVE BMPs CONSIDERED DURING PRELIMINARY DESIGN

Several alternative volume-based BMPs were considered in the initial design phase. These various BMPs included utilizing horizontal rows of HDPE pipe, a cast-in-place reinforced concrete vault, and pre-manufactured concrete vaults utilizing StormTrap (manufactured by StormTrap Inc.) or StormVault (manufactured by Conspan Inc.). In addition to the various volume-based BMPs considered for the project, several flow-based BMP products were also sized in order to provide 100% of the required water quality treatment flow rate. These products included hydrodynamic separators manufactured by CDS Technologies Inc., Vortechnics Inc., and Bioclean Environmental Services Inc. (which manufacturers the Baffle Box).

Approximate costs were determined for several volume-based and flow-based BMPs that would individually provide 100% of the required treatment volume or flow rate (per the numeric sizing criteria). The preliminary costs (including only the material cost of each associated BMP) are summarized in the table below:

**Table 3.2.1**

**Summary of Preliminary Material Costs for Alternative BMPs**

| Manufacturer | Model Type | Material Cost | Volume or Flow-Based BMP? |
|---|---|---|---|
| StormTrap (StormTrap) | 224 10-ft DoubleTrap Units | $1,305,373 | Volume |
| StormVault (Conspan) | 312 LF Triple-Cell 24ft span x 10ft rise | $1,350,000 | Volume |
| CDS Unit (CDS Technologies) | PSWC 56_68 | $51,600 | Flow |
| Vortechnics Unit (Vortechnics) | PC 1319 | $60,000 | Flow |
| Baffle Box (Bioclean) | NSBB 8-12-96 | $30,000 | Flow |
| Stormfilter (Stormwater Management Inc) | 479 StormFilter Cartridges | $500,000 | Flow |

As suggested above, the approximate cost of a volume-based BMP that would act as the sole treatment device is $1.3 million. This cost is for the facility material only, as installation would be in addition to that, as would backfill and the entire connecting storm drain conduits, sampling equipment, and other items required as part of the design (the overall constructed cost would likely exceed $2 million. The chosen alternative is discussed within the following section of this report, and final construction costs are provided in Appendix G.

### 3.3 ACTUAL BMP(s) CHOSEN FOR FINAL DESIGN AND CONSTRUCTION

After considering the various alternatives, both volume-based and flow-based, it was decided during conversations between Rick Engineering Company and the County of San Diego (who also discussed the various options with the RWQCB) that a combination of volume-based and flow-based BMPs would be utilized. A flow-based BMP will be sized to treat 100% of the required water quality treatment flow rate, and a volume-based BMP will then provide additional treatment to the maximum extent practicable (MEP) considering both physical and fiscal constraints. This final design approach was summarized in a letter dated 08/04/05, prepared by Rick Engineering Company and addressed to the County of San Diego, that was intended to answer specific questions that the State Water Quality Control Board (SWQCB) had regarding the final selection of the treatment facility.

Of the various flow-based BMPs considered, it was decided that a Vortechnics Model would provide the flow-based treatment as it has become the preferred hydrodynamic separator with the RWQCB and appears to provide higher pollutant removal rates as compared to the alternatives. In regards to providing the volume-based portion of the overall underground water quality detention basin, it appeared that using a collection of pre-manufactured StormTrap units would provide the most cost-effective approach to maximizing the volume provided.

Using the combination of a Vortechnics Model PC 1319 placed upstream of the StormTrap detention vault provides a treatment train which will collect the larger pollutants of concern at the Vortechnics unit and will help focus a majority of maintenance activity to this upstream unit. The treatment train is located off-line from the mainline storm drain system, and will receive low-flow runoff from a modified cleanout with a weir acting as a diversion structure for these low-flow storm events. Collectively, the two units placed in series exceed the water quality treatment requirements of the County SUSMP.

Refer to Appendix D for the water quality treatment flowrate that is provided by the Vortechnics Hydrodynamic Separator and Appendix E for the water quality treatment volume provided by the StormTrap Detention Vault. Additional information for each of these manufacturers is also included within Appendices D and E.

# 4.0 DESIGN CONSTRAINTS AND BASIN CONFIGURATION

## 4.1 DESIGN CONSTRAINTS

With the type of BMP(s) chosen, the location and configuration of the facility was constrained based on the existing storm drain system and proposed FAA project drainage system. The project needed to provide the facility at a location where the proposed on-site system for the FAA project could be conveyed to a location upstream of the facility such that the existing runoff from the southern sub-basin and the proposed runoff from the northern sub-basin would converge and each area would be treated through the underground facility. Additionally, the project could not encroach on the existing runway, or into the SDGE easement to the north. It was therefore determined that the location where both sub-basins could come together was at the existing manhole just to the north of the runway.

Since the proposed project would collect runoff from the existing storm drain that runs south to north under the runway, the existing invert elevation (IN) at the aforementioned manhole set the upstream vertical elevation for the proposed BMP facility. The downstream vertical elevation was also fixed based on the existing invert elevation (OUT) at the downstream Type 'F' catch basin.

With the existing storm drain system undersized, the project was carefully designed in order to minimize hydraulic impacts that the project would have on the existing system. The project is intended for water quality purposes, and therefore has not been designed to increase conveyance for flood control purposes. However, there may be some unmeasured benefit due to the additional storage created within the underground storm drain system due to the proposed project. The new mainline system was sized to the maximum allowed without "telescoping," otherwise defined as providing a storm drain diameter larger than the downstream system. The downstream system leaving the project boundary was surveyed as a 36-inch RCP, therefore a 36-inch RCP has been specified for the mainline system throughout the project limits.

## 4.2 CONFIGURATION OF THE COMBINED TREATMENT FACILITY

The configuration of the treatment facility had to consider site constraints and preferred design criteria as it relates to volume-based treatment. The proposed storm drain system will collect runoff at the existing manhole just north of the existing runway. Runoff will then flow to a modified cleanout that is to act as a diversion box. From here, low-flows are diverted one direction, while large-flows overtop the diversion weir and continue through the proposed 36-inch RCP mainline and eventually connects with the existing Type 'F' catch basin where an existing 36" RCP discharges flow from the airport towards the downstream off-site storm drain system. Low-flows which are diverted by the weir are conveyed via a 30-inch RCP into the proposed Vortechnics Model PC 1319. Here, the flows travel through a collection of screens, baffles, weirs, and orifices until exiting the downstream end of the unit. At the downstream end of the Vortechnics unit, a 30-inch RCP conveys these treated flows into the StormTrap detention vault.

### 4.2.1 Detention Vault

Within the vault, storage of the flows begins to occur as the water surface elevation rises as flows continue to enter. A low-flow outlet plate is located at the downstream end of the detention vault to help regulate the outgoing flow-rate such that a 24-72 hour drawdown time is achieved for the detained flows. As the rate of runoff begins to exceed the treatment capacity of the combined treatment system, flow will exit the top (southeast) corner of the detention vault and reenter the mainline system. This outlet location acts as an overflow spillway and has been provided to help minimize backup through the Vortechnics unit when the storage vault nears its capacity (therefore allowing continued flow and treatment through the Vortechnics unit).

The detention vault is configured with a stretched length-to-width ratio, as recommended for all water quality treatment basins. The length-to-width ratio helps provide time for pollutants to settle prior to reaching the downstream outlet structure. The actual dimensions of the vault are 50'4 ½" L x 31'6 ¼" W x 5' H, resulting in a length-to-width ratio of 1.6-to-1.

#### 4.2.1.1 Drawdown Time and Low-flow Outlet Structure

The design of the basin does not include any areas of permanent pools. This has been done to allow the basin to fully drain and to help in the prevention/reduction of vector control concerns. The low-flow outlet structure will be sized to allow for complete drawdown of the water quality volume within 24-72 hours. Since the basin is located underground and will require specific inspections to verify drawdown times, the design approach was to target the lower end of typical drawdown times. A 50% clogging factor has been assumed in the drawdown time calculations due to the small size of the low-flow outlet.

An iterative procedure was used to determine what size would be required for the low-flow outlet structure to provide the desired drawdown time. The results of the final drawdown time calculation are summarized below:

**Table 4.2.1.1**

**Summary of Drawdown Time Calculation and Low-flow Outlet Structure**

| | |
|---|---|
| Size of Low-Flow Outlet Structure: | 24-inch RCP, Steel Plated with 2" (wide) by 24" (high) vertical notch opening from flowline of outlet pipe |
| Total Drawdown Time ($T_{TOT}$): | 34 hours |

The iterative process for sizing the low-flow outlet structure resulted in a final design that provides a steel plate that will be bolted over-top of the 24-inch RCP outlet pipe. The plate will have a vertical notch with the following dimensions: 2" x 24" (width x height). This design was preferred over the use of a circular opening which would sit lower over the outlet pipe, as the vertical notch will help allow the basin to drain in the event that several inches of sediment and/or debris accumulate at the invert of the outlet structure. The actual drawdown time of the detention vault may be monitored such that modifications to the steel plate could allow adjusting the drawdown time up or down, as desirable.

A copy of the drawdown time calculation is provided in Appendix F.

# 5.0 HYDRAULICS

There are several components of the project that require hydraulic considerations. However, the project facility is located along the reach of an existing storm drain system. Therefore, the pipe sizes throughout the project were limited to the diameter of the downstream storm drain system. The size and material of the existing downstream facility is a 36-inch RCP. As a result, the project has provided a 36-inch RCP throughout the main storm drain alignment. Runoff that flows through this section of 36-inch RCP will be limited to the maximum capacity of a 36-inch opening with approximately 19-feet of available head (HW depth = 309.5 – 290.35). Based on the inlet control chart for a 36-inch pipe with a manning's 'n' value of 0.013, the capacity is approximately 150 cfs.

The upstream existing storm drain that will be conveyed through the proposed project was originally a 30-inch CMP, later slip-lined with PVC resulting in an equivalent size of a 19" PVC pipe. Runoff that flows through this storm drain is therefore limited to the maximum capacity of a 19-inch opening with approximately 7-feet of available head (HW depth = 313.0 – 306.0). Based on the inlet control chart for a 19-inch pipe with a manning's 'n' value of 0.013, the capacity is approximately 25 cfs.

When you compare the results of the 100-year, 6-hour modified rational method analysis, it is clear that the anticipated flowrate exceeds the capacity of both the existing and proposed system. As a result, the hydraulic grade line will exceed finished grade throughout the length of the project, as well as in the existing system upstream. Therefore, it should be expected that ponding of water will occur at many of the inlet collection points throughout the drainage area for this system. Since the project design was constrained to accommodate the existing storm drain both upstream and downstream of the project area, this project was not able to alleviate this previously existing hydraulics issue.

# 6.0 INSPECTION, OPERATION, AND MAINTENANCE OF FACILITY

## 6.1 Initial Inspections

An initial inspection of the facility should be performed following the first large storm event. The inspection should include visual checks throughout the facility, specifically at the following locations: the existing manhole at the upstream end of the proposed facility, the diversion box, the Vortechnics unit, the detention vault, and at the existing Type 'F' catch basin. These checks should ensure that each junction/structure appears to be functioning properly and without unexpected debris accumulation.

The long-term effectiveness of the underground water quality detention basin will partially be dependent on the frequency of inspections and maintenance activities. It will be important to inspect the basin after the first large storm event to determine if the desired drawdown (residence) time is achieved and functioning properly (48-72 hours). If the drawdown time (within the detention vault) is not within the desired parameters, then modifications should be made to the low-flow orifice structure to better provide the desired timeframe. Close attention should also be made to the appearance of possible clogging to the low-flow structure. If it appears that there may be a potential problem with clogging, then additional steps should be taken to help prevent such an occurrence (or increase the inspection frequency until a better comfort level is reached).

## 6.2 Periodic Inspections and Maintenance

Periodic maintenance for a typical detention basin is routinely related to vegetation management, and has been summarized by CASQA based on recent Caltrans studies. However, CASQA does not provide any information regarding underground detention basins. It is anticipated that the majority of inspection and maintenance activity for the detention vault will be similar to that of a hydrodynamic separator (such as the Vortechnics unit included as part of this overall treatment facility). Since the hydrodynamic separator has been placed upstream of the detention vault with the intent of collecting the larger pollutants, the detention vault may require less frequent maintenance as compared to the hydrodynamic separator. However, it will still be important to inspect both facilities each time inspections are performed.

### 6.2.1 Detention Vault (StormTrap)

The following list is an abbreviated version of typical inspection and maintenance "activities and frequencies" specified by CASQA for detention basins. The list has been modified as applicable for an underground detention basin:

- Schedule semiannual inspection for the beginning and end of the wet season for standing water, sediment accumulation, and trash and debris.
- Remove accumulated trash and debris in the basin and around the outlet structure.
- Remove sediment when the accumulated sediment volume exceeds 6-inches in depth.

Specifically, the basin should be maintained when 6-12 inches of sediment deposition has occurred, or if debris accumulation at the low-flow outlet structure is preventing drawdown within the basin. Maintenance cleaning is expected to use a vactor truck to vacuum out accumulated sediment and debris. Until inspections reveal a site-specific frequency for maintenance, it could be assumed the detention vault might require full-cleaning once every year or two. However, it may prove necessary to vactor the northeast corner adjacent to the low-flow outlet structure more frequently (for example, vactor out this portion of the detention vault as frequently as the Vortechnics Unit is cleaned, as described below).

### 6.2.2 Hydrodynamic Separator (Vortechnics Unit)

The following list is summarizes the typical inspection and maintenance "activities and frequencies" specified by the manufacturer for this type of treatment unit.

- Schedule semiannual inspection for the beginning and end of the wet season to observe sediment accumulation, trash and debris, and if the "floating hydrocarbon layer accumulates to an appreciable thickness."

- The system should be cleaned when inspection reveals that the sediment depth has accumulated to within six inches of the dry-weather water surface elevation. The water depth to sediment is determined by taking two measurements with a stadia rod: one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. When the difference between these two measurements is six inches or less, the system should be cleaned out.

- For optimum performance, the system should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of a spill anywhere in the drainage area that is tributary to the facility, the system should be cleaned immediately.

Specifically, the maintenance method for cleaning the hydrodynamic separator will also use a vactor truck. Until inspections reveal a site-specific frequency for maintenance, it could be assumed the hydrodynamic separator may require full-cleaning one or two times per year.

An overall cost estimate for maintenance of the combined water quality treatment facility may be formed by summing the costs for the annual inspections, maintenance, administration, and materials that would be anticipated for the basin. Records of all inspection and maintenance activities should be kept for a minimum of 5 years, and should include the date of activity, observations, services performed, and any additional comments.

## 7.0 CONCLUSION

The design of the underground water quality basin was based on meeting and/or exceeding the County of San Diego SUSMP requirements for the total drainage area that is tributary to the existing downstream storm drain system (at the center of the northern airport property boundary). Important constraints with which the design was based upon were the inflow and outflow invert elevations and size of the existing upstream and downstream storm drain system. The project was also required to coordinate with the above-ground FAA project that was to be built simultaneously, and provide treatment for runoff from that project as well.

The original goal for the project was to provide treatment through an underground detention basin, which is typically achieved using a volume-based treatment approach. However, during the design of the project, it was determined that a combination of physical and fiscal constraints made providing treatment through a combined flow-based and volume-based facility placed in series was the best alternative to meet and exceed the SUSMP requirements to the Maximum Extent Practicable (MEP). The combined treatment facility is comprised of a hydrodynamic separator (Vortechnics Model PC 1319) and a detention vault (StormTrap Precast Units).

The total watershed tributary to the proposed facility is 89.9 acres, comprised of nearly 100% impervious areas. The facility was designed to the entire watershed, assuming ultimate land use and a runoff coefficient of 0.90. Runoff from the south half of the watershed is conveyed to the facility via an existing 19-inch PVC under the existing runway. Runoff from the northern-half of the watershed is collected via an on-site storm drain system that is to be installed as part of the FAA project being built at the same time as the water quality treatment facility. The flows from the southern and northern portions of the watershed are confluenced at an existing manhole that is to be converted to a proposed inlet as part of the FAA project. This location is the upstream end of the proposed underground water quality project.

The proposed project collects the combined flows and conveys them through a diversion structure (modified Type A-8 cleanout) that directs low flows through the proposed facility, and allows larger flows to continue downstream through the main line 36-inch RCP alignment. The low flows exit the diversion structure and enter the hydrodynamic separator where pollutants settle out as water travels through a collection of screens, baffles, weirs, and orifices until exiting the downstream end of the unit. At the downstream end of the Vortechnics unit, a 30-inch RCP conveys these treated flows into the StormTrap detention vault. The detention vault provides a second opportunity for pollutants to settle as the water is detained for an extended period as a low-flow restrictor plate at the downstream end of the vault controls outflow.

Hydraulics throughout the system is limited to the existing systems both upstream and downstream of the proposed project. Since the existing downstream system is only 36-inch (and telescoping is not allowed), the storm drain through the mainline alignment for the project is a 36-inch RCP.

In order for the proposed project to operate as designed, periodic inspections and maintenance will be required. The required frequency of the inspections and maintenance activities will become more evident following inspections and maintenance cleanings in the first few years of service. At this time, it is recommended that the facility be inspected following the first large storm event following completion of the project, and periodically on a semi-annual basis thereafter. The semi-annual inspections should be performed at the beginning and end of the rainy season. During these inspections, the diversion structure, hydrodynamic separator, detention vault, low-flow restrictor plate, and downstream Type 'F' catch basin should all be observed. Frequency of maintenance will also become more clear following these inspections, however, it is currently anticipated that the hydrodynamic separator should be maintained 1-2 times per year, and the detention vault once every one or two years. Each of these frequencies may increase and/or decrease, as site-specific conditions become evident.

Following the completion of the project, a monitoring and sampling phase of the overall grant project will provide input as to the performance of the facility. Sampling equipment will be located at the upstream end of the treatment facility (adjacent to the diversion structure) that will monitor untreated flows entering the facility. Similar sampling equipment will also be provided at the downstream end of the facility (adjacent to the low-flow restrictor plate) that will monitor the treated flows exiting the treatment facility. Separate documents address the proposed monitoring and sampling of the facility, known as the QAPP and SAP for the project (refer to the table of contents for detailed reference document information).

Refer to the following appendices and map pockets for backup information discussed throughout this report and Appendix H for a plan view schematic of the proposed project.

# APPENDIX A

## Vicinity Map


RICK
ENGINEERING COMPANY
PREPARED BY
GIS SERVICES DIVISION

1 inch equals 2,500 feet

0 1,100 2,200 4,400 Feet

EXHIBIT DATE: 10/10/06 REC JN: 14804-E
W:\14804\14804-E_Palomar_Airport\x14804E_GIS_VicinityMap.mxd

# VICINITY MAP FOR McCLELLAN-PALOMAR AIRPORT PROJECT

THIS PROJECT LOCATED WITHIN THE CITY OF CARLSBAD

# APPENDIX B

## Modified Rational Method Computer Output

## For

## 100-year, 6-hour Storm Event

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****************************************************************************
          RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
          Reference: SAN DIEGO COUNTY FLOOD CONTROL DISTRICT
                       2003,1985,1981 HYDROLOGY MANUAL
       (c) Copyright 1982-2003 Advanced Engineering Software (aes)
           Ver. 1.5A Release Date: 01/01/2003  License ID 1261

                         Analysis prepared by:

                        RICK ENGINEERING COMPANY
                            5620 Friars Road
                       San Diego, California 92110
                      619-291-0707   Fax 619-291-4165

 ************************** DESCRIPTION OF STUDY **************************
 * COUNTY OF SAN DIEGO - PALOMAR AIRPORT;  J-14804E                        *
 * 100-YEAR PEAK STORM EVENT                                               *
 * ULTIMATE LAND USE                                                       *
 **************************************************************************

  FILE NAME: 100_100U.DAT
  TIME/DATE OF STUDY: 19:23 10/10/2006
----------------------------------------------------------------------------
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
----------------------------------------------------------------------------
  2003 SAN DIEGO MANUAL CRITERIA

  USER SPECIFIED STORM EVENT(YEAR) = 100.00
  6-HOUR DURATION PRECIPITATION (INCHES) =   2.750
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  12.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  SAN DIEGO HYDROLOGY MANUAL "C"-VALUES USED FOR RATIONAL METHOD
  NOTE: USE MODIFIED RATIONAL METHOD PROCEDURES FOR CONFLUENCE ANALYSIS
  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN-  / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.  (FT)     (FT)     SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
 1   30.0     20.0     0.018/0.018/0.020  0.67    2.00 0.0313 0.167 0.0150
 2   20.0     15.0     0.020/0.020/0.020  0.50    1.50 0.0100 0.125 0.0180

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.50 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*

****************************************************************************
  FLOW PROCESS FROM NODE    100.00 TO NODE    101.00 IS CODE = 21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
============================================================================
  *USER SPECIFIED(SUBAREA):
  STREETS & ROADS (CURBS/STORM DRAINS) RUNOFF COEFFICIENT = .9000
  S.C.S. CURVE NUMBER (AMC II) =   0
  INITIAL SUBAREA FLOW-LENGTH(FEET) =     70.00
  UPSTREAM ELEVATION(FEET) =    325.20
  DOWNSTREAM ELEVATION(FEET) =    323.80
```

```
ELEVATION DIFFERENCE(FEET) =      1.40
SUBAREA OVERLAND TIME OF FLOW(MIN.) =    2.391
 100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  7.246
NOTE: RAINFALL INTENSITY IS BASED ON Tc = 5-MINUTE.
SUBAREA RUNOFF(CFS) =     12.39
TOTAL AREA(ACRES) =      1.90   TOTAL RUNOFF(CFS) =     12.39

****************************************************************************
 FLOW PROCESS FROM NODE    101.00 TO NODE    110.00 IS CODE =  31
----------------------------------------------------------------------------
 >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
 >>>>>USING COMPUTER-ESTIMATED PIPESIZE (NON-PRESSURE FLOW)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   320.00  DOWNSTREAM(FEET) =   306.00
 FLOW LENGTH(FEET) =  2400.00   MANNING'S N =  0.013
 DEPTH OF FLOW IN  24.0 INCH PIPE IS  15.6 INCHES
 PIPE-FLOW VELOCITY(FEET/SEC.) =   5.73
 ESTIMATED PIPE DIAMETER(INCH) =  24.00    NUMBER OF PIPES =   1
 PIPE-FLOW(CFS) =     12.39
 PIPE TRAVEL TIME(MIN.) =    6.98    Tc(MIN.) =    9.37
 LONGEST FLOWPATH FROM NODE    100.00 TO NODE    110.00 =  2470.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE    110.00 TO NODE    110.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  4.833
 *USER SPECIFIED(SUBAREA):
 STREETS & ROADS (CURBS/STORM DRAINS) RUNOFF COEFFICIENT = .9000
 S.C.S. CURVE NUMBER (AMC II) =    0
 AREA-AVERAGE RUNOFF COEFFICIENT = 0.9000
 SUBAREA AREA(ACRES) =    41.00   SUBAREA RUNOFF(CFS) =  178.33
 TOTAL AREA(ACRES) =      42.90   TOTAL RUNOFF(CFS) =  186.60
 TC(MIN.) =    9.37

****************************************************************************
 FLOW PROCESS FROM NODE    110.00 TO NODE    120.00 IS CODE =  41
----------------------------------------------------------------------------
 >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
 >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   306.00  DOWNSTREAM(FEET) =   290.68
 FLOW LENGTH(FEET) =    460.00   MANNING'S N =  0.013
 ASSUME FULL-FLOWING PIPELINE
 PIPE-FLOW VELOCITY(FEET/SEC.) =  70.69
 PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
 GIVEN PIPE DIAMETER(INCH) =  22.00    NUMBER OF PIPES =   1
 PIPE-FLOW(CFS) =    186.60
 PIPE TRAVEL TIME(MIN.) =   0.11    Tc(MIN.) =    9.48
 LONGEST FLOWPATH FROM NODE    100.00 TO NODE    120.00 =  2930.00 FEET.

****************************************************************************
 FLOW PROCESS FROM NODE    120.00 TO NODE    120.00 IS CODE =  81
----------------------------------------------------------------------------
 >>>>>ADDITION OF SUBAREA TO MAINLINE PEAK FLOW<<<<<
============================================================================
  100 YEAR RAINFALL INTENSITY(INCH/HOUR) =  4.797
 *USER SPECIFIED(SUBAREA):
 STREETS & ROADS (CURBS/STORM DRAINS) RUNOFF COEFFICIENT = .9000
 S.C.S. CURVE NUMBER (AMC II) =    0
```

```
 AREA-AVERAGE RUNOFF COEFFICIENT = 0.9000
 SUBAREA AREA(ACRES) =    47.00   SUBAREA RUNOFF(CFS) =  202.92
 TOTAL AREA(ACRES) =      89.90   TOTAL RUNOFF(CFS) =  388.13
 TC(MIN.) =   9.48

****************************************************************************
 FLOW PROCESS FROM NODE    120.00 TO NODE    130.00 IS CODE =  41
----------------------------------------------------------------------------
 >>>>>COMPUTE PIPE-FLOW TRAVEL TIME THRU SUBAREA<<<<<
 >>>>>USING USER-SPECIFIED PIPESIZE (EXISTING ELEMENT)<<<<<
============================================================================
 ELEVATION DATA: UPSTREAM(FEET) =   290.35  DOWNSTREAM(FEET) =   280.43
 FLOW LENGTH(FEET) =   206.65   MANNING'S N =  0.013
 ASSUME FULL-FLOWING PIPELINE
 PIPE-FLOW VELOCITY(FEET/SEC.) =  54.91
 PIPE FLOW VELOCITY = (TOTAL FLOW)/(PIPE CROSS SECTION AREA)
 GIVEN PIPE DIAMETER(INCH) =  36.00    NUMBER OF PIPES =   1
 PIPE-FLOW(CFS) =    388.13
 PIPE TRAVEL TIME(MIN.) =   0.06    Tc(MIN.) =    9.54
 LONGEST FLOWPATH FROM NODE    100.00 TO NODE    130.00 =  3136.65 FEET.
============================================================================
 END OF STUDY SUMMARY:
 TOTAL AREA(ACRES)      =    89.90  TC(MIN.) =      9.54
 PEAK FLOW RATE(CFS)    =    388.13
============================================================================
============================================================================
 END OF RATIONAL METHOD ANALYSIS
```

# APPENDIX C

## Numerical Sizing Criteria Calculations

RICK™
ENGINEERING COMPANY
5620 Friars Road
San Diego, California 92110-2596
Tel: (619) 291-0707
Fax: (619) 291-4165

Date 08/04/05
Job No. 14804-E
Page
Done By
Checked By

# WATER QUALITY TREATMENT CALCULATIONS:

TRIBUTARY AREA: Area tributary from South side of Runway ℄ = 42.9 AC.

Area tributary from North side of Runway ℄ = 47.0 AC.

∴ TOTAL TRIBUTARY AREA = 89.9 AC.

RUNOFF COEFFICIENT: C = 0.90 (~ 100% Imperviousness)

NUMERIC SIZING CRITERIA PER SUSMP:

using flow-based ⇒ $Q_{T_{req'd}} = C\,i\,A$ , $i = 0.2$ in/hr

∴ $Q_T = (0.9)(0.2 \text{ in/hr})(89.9 \text{ AC}) = 16.2$ cfs

using volume-based ⇒ $WQ_{V_{REQ'D}} = P_{85\%} \cdot C A$

∴ $WQ_V = \left(\frac{.65''}{12}\right)(0.9)(89.9 \text{ AC}) = 4.4$ AC.FT

# APPENDIX D

## Vortechnics Stormwater Treatment System: Water Quality Treatment Capacities, Details, and Notes

## [Hydrodynamic Separator]

**FLOW CALCULATIONS**
**Palomar Airport**
**San Diego, CA**
**Model PC1319**

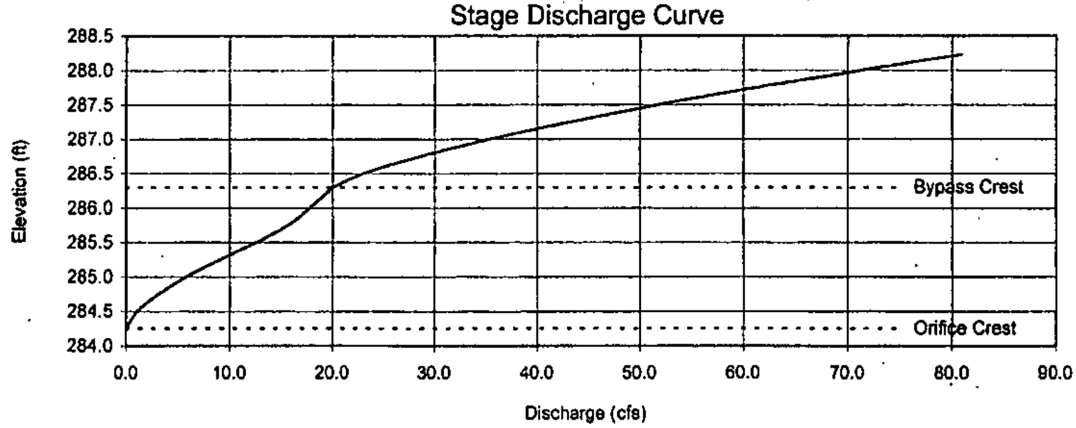
**Preliminary**

| Vortechs Orifice | Vortechs Weir | Bypass Weir |
|---|---|---|
| Cd = 0.56 | Cd = 3.33 | Cd = 3.3 |
| A ($ft^2$) = 3.73 | Weir Crest Length (ft) = 0 | Weir Crest Length (ft) = 5.67 |
| Crest Elevation (ft) = 284.25 | Crest Elevation (ft) = 288.17 | Crest Elevation (ft) = 286.3 |

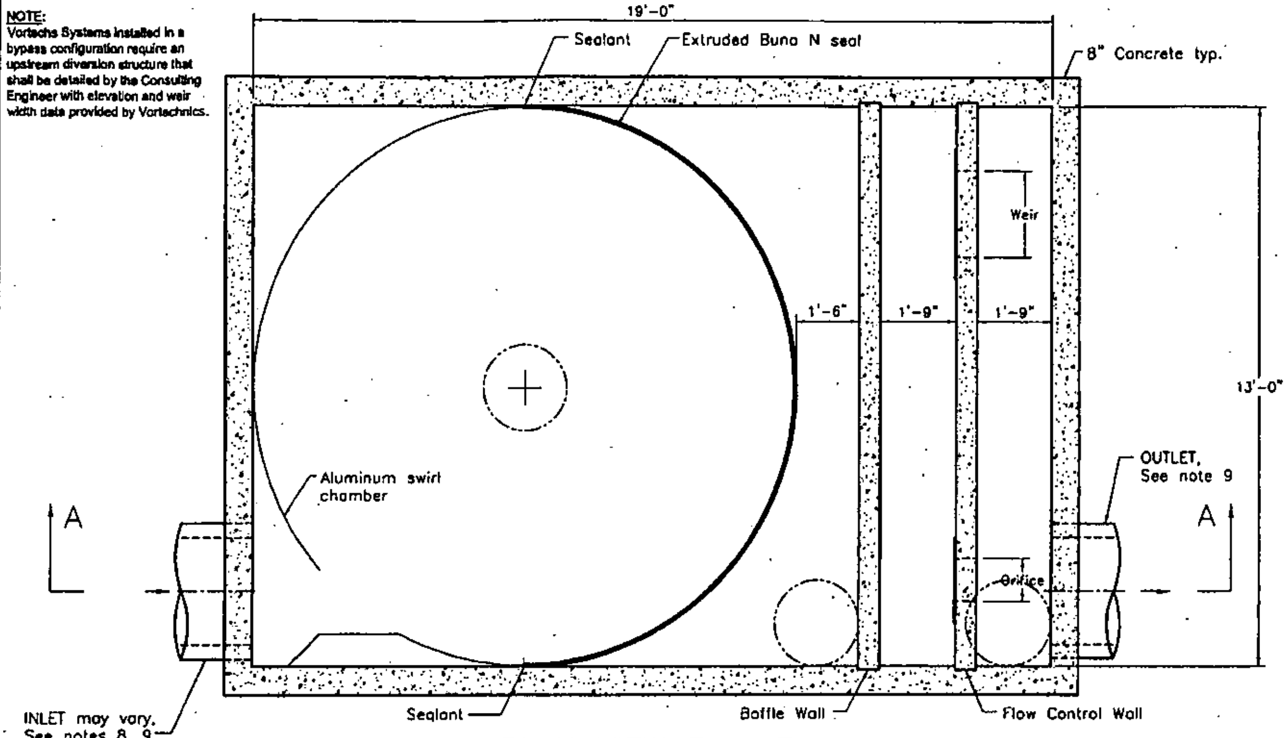
| Head (ft) | Elevation (ft) | Orifice Flow (cfs) | Weir Flow (cfs) | Bypass Flow (cfs) | Total Flow (cfs) |
|---|---|---|---|---|---|
| 0.00 | 284.25 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.25 | 284.50 | 1.12 | 0.00 | 0.00 | 1.12 |
| 0.50 | 284.75 | 3.18 | 0.00 | 0.00 | 3.18 |
| 0.75 | 285.00 | 5.84 | 0.00 | 0.00 | 5.84 |
| 1.00 | 285.25 | 9.00 | 0.00 | 0.00 | 9.00 |
| 1.25 | 285.50 | 12.57 | 0.00 | 0.00 | 12.57 |
| 1.50 | 285.75 | 15.67 | 0.00 | 0.00 | 15.67 |
| 1.75 | 286.00 | 17.76 | 0.00 | 0.00 | 17.76 |
| 2.00 | 286.25 | 19.64 | 0.00 | 0.00 | 19.64 |
| 2.05 | 286.30 | 19.97 | 0.00 | 0.00 | 19.97 |
| 2.25 | 286.50 | 21.35 | 0.00 | 1.71 | 23.06 |
| 2.50 | 286.75 | 22.93 | 0.00 | 5.70 | 28.64 |
| 2.75 | 287.00 | 24.42 | 0.00 | 11.03 | 35.44 |
| 3.00 | 287.25 | 25.81 | 0.00 | 17.41 | 43.22 |
| 3.25 | 287.50 | 27.14 | 0.00 | 24.69 | 51.82 |
| 3.50 | 287.75 | 28.40 | 0.00 | 32.77 | 61.17 |
| 3.75 | 288.00 | 29.61 | 0.00 | 41.58 | 71.19 |
| 3.98 | 288.23 | 30.67 | 0.00 | 50.23 | 80.90 |

Calculated by: JKR 6/28/2005 Checked by:

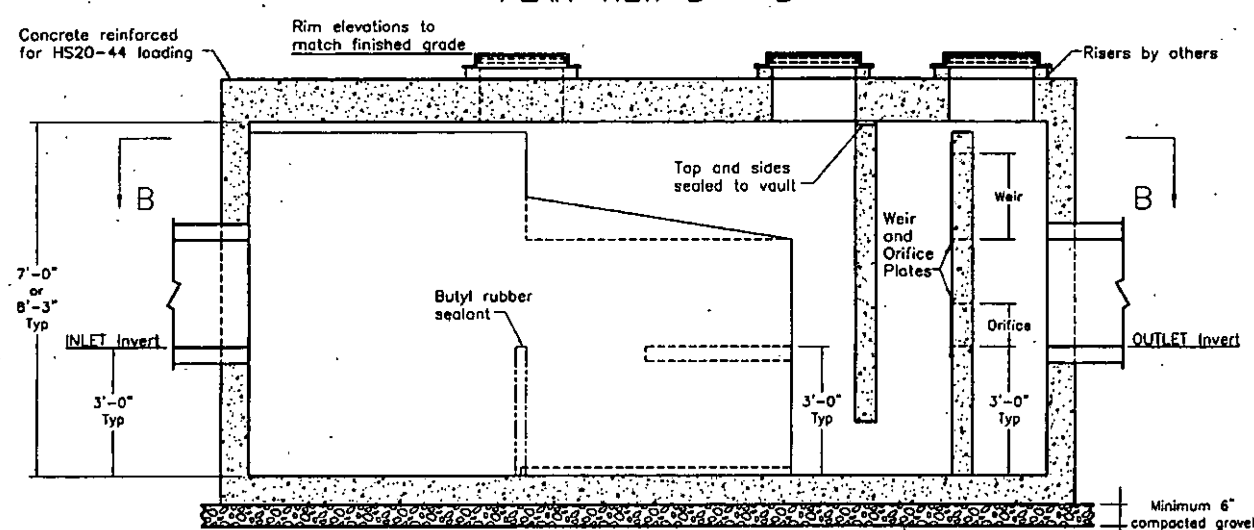
Vortechs™ System
Stage Discharge Curve



NOTE:
Vortechs Systems installed in a bypass configuration require an upstream diversion structure that shall be detailed by the Consulting Engineer with elevation and weir width data provided by Vortechnics.




PLAN VIEW B – B




SECTION A – A

NOTES:

1. Stormwater Treatment System (SWTS) shall have:
   Peak treatment capacity: 30 cfs
   Sediment storage: 9.0 cu yd
   Sediment chamber dia: 13' min
2. SWTS shall be contained in one rectangular structure
3. SWTS shall remove 80% of the net annual TSS loading based on a 50 micron size particle.
4. SWTS shall retain floatables and trapped sediment up to and including peak treatment capacity
5. SWTS inverts in and out shall be at the same elevation
6. SWTS shall not be compromised by effects of downstream tailwater
7. SWTS shall have no internal components that obstruct maintenance access
8. Inlet pipe must be perpendicular to the structure
9. Pipe orientation may vary; see site plan for size and location
10. Purchaser shall not be responsible for assembly of unit
11. Manhole frames and perforated covers supplied with system, not installed
12. Purchaser to prepare excavation and provide lifting equipment
13. Contact Vortechnics @ (207) 885-9830 for ordering information

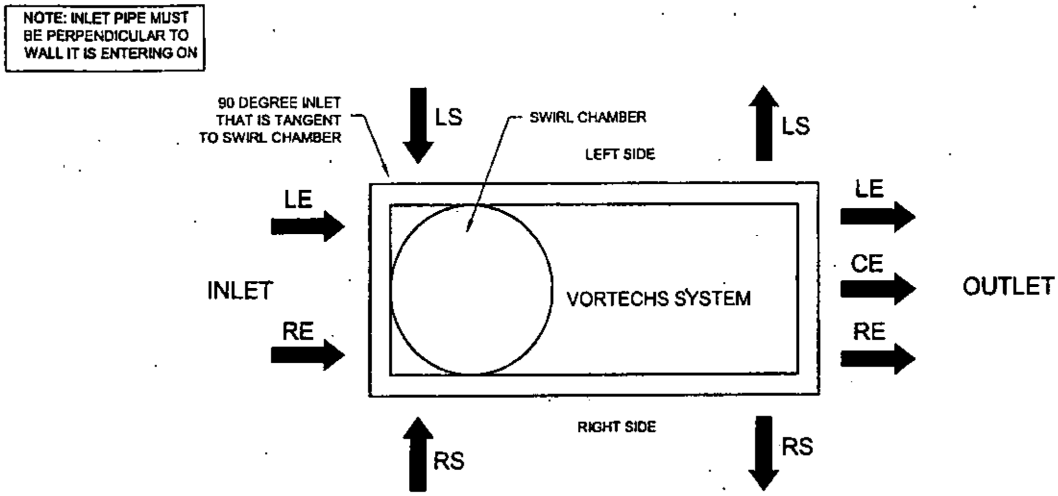


Vortechnics
200 Enterprise Drive
Scarborough, ME 04074
Tel.: 207-885-9830
Fax: 207-885-9825

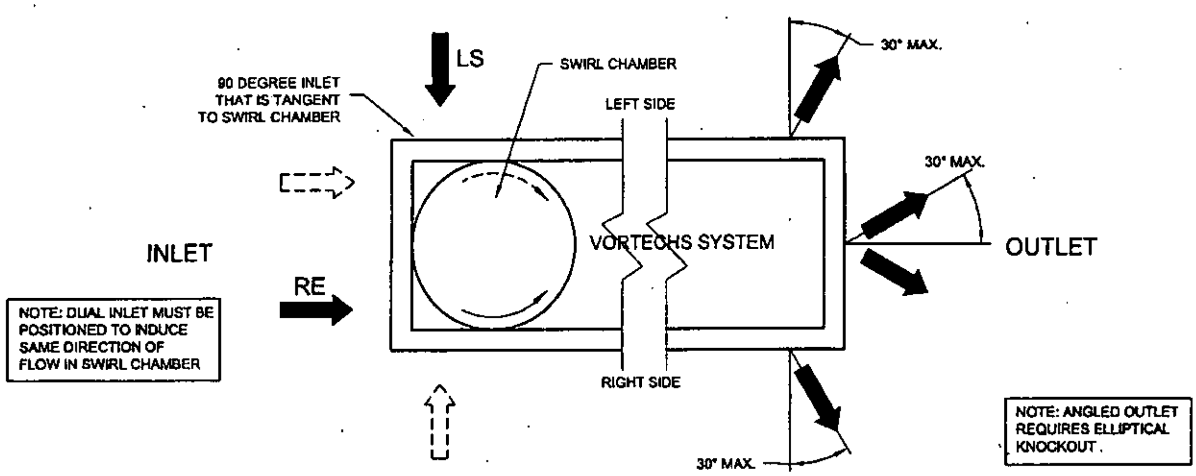
STANDARD DETAIL
STORMWATER TREATMENT SYSTEM
VORTECHS® MODEL PC1319 U.S. PATENT No. 5,759,415

PROPRIETARY INFORMATION - NOT TO BE USED FOR CONSTRUCTION PURPOSES

| DATE: 01/17/02 | SCALE: 1/4" = 1'-0" | FILE NAME: STD19K | DRAWN BY: DMF | CHECKED BY: NDG |
|---|---|---|---|---|




TYPICAL INLET/OUTLET ORIENTATION OPTIONS




DUAL INLET ORIENTATION OPTIONS

ANGLED OUTLET ORIENTATION OPTIONS

**ORIENTATION KEY**

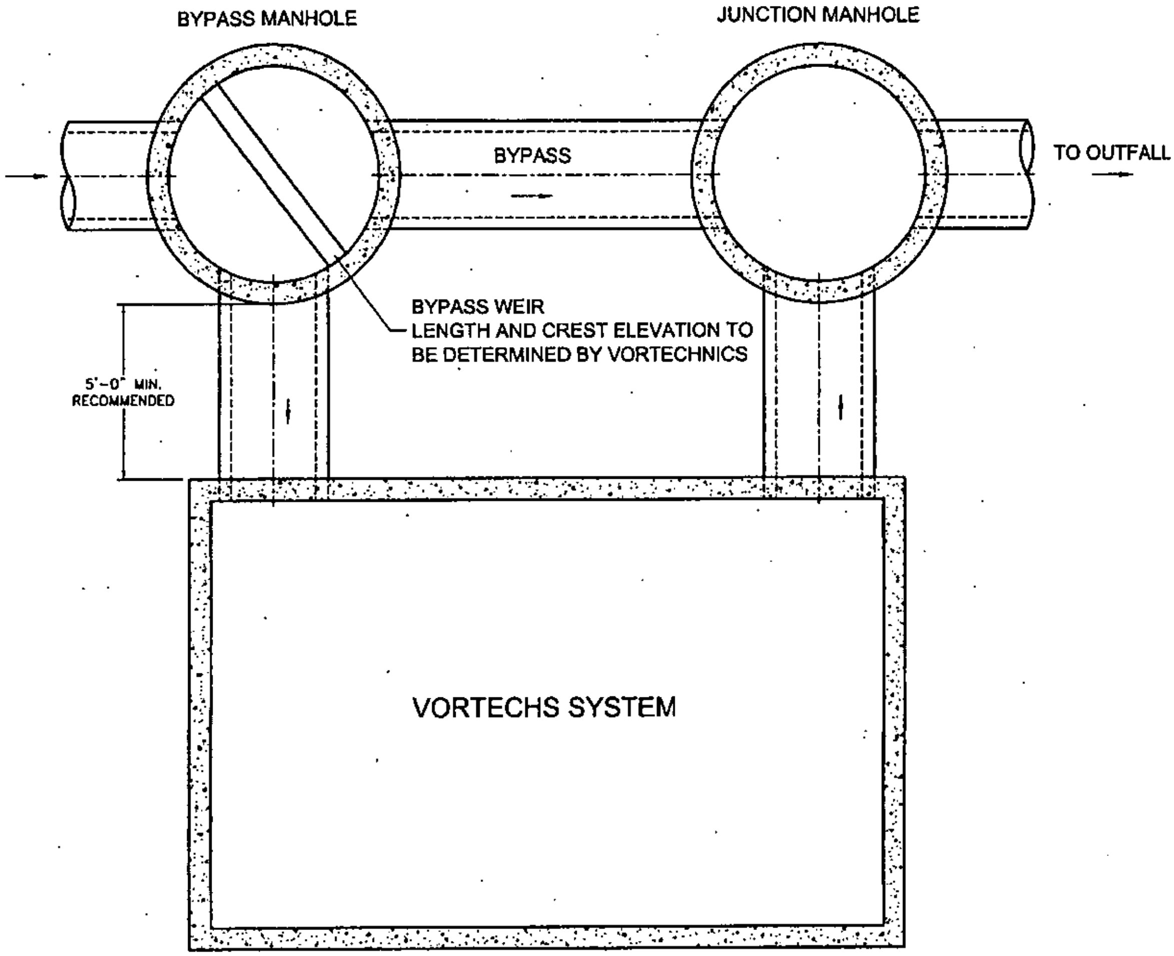
LE = LEFT END
RE = RIGHT END
LS = LEFT SIDE
RS = RIGHT SIDE
CE = CENTER END



Vortechnics
200 Enterprise Drive
Scarborough, ME 04074
Tel.: 207-885-9830
Fax: 207-885-9825

TYPICAL VORTECHS® SYSTEM ORIENTATIONS

| DATE: 06/07/05 | SCALE: NONE | FILE NAME: VXTYP ORIENT | DRAWN BY: SEP | CHECKED BY: NDG |
|---|---|---|---|---|




ACTUAL ORIENTATION AND LAYOUT MAY VARY
DUE TO SITE SPECIFIC CONSIDERATIONS



Vortechnics
200 Enterprise Drive
Scarborough, ME 04074
Tel.: 207-885-9830
Fax: 207-885-9825

# TYPICAL BYPASS LAYOUT
# VORTECHS® STORMWATER TREATMENT SYSTEM

| DATE: 10/15/04 | SCALE: NONE | FILE NAME: TYPBPLO | DRAWN BY: GMC | CHECKED BY: NDC |
|---|---|---|---|---|

Vortechnics

Total Stormwater Solutions™

Vortechs® Stormwater Treatment System

# TECHNICAL DESIGN MANUAL

INCLUDING:

- DESIGN & OPERATION
- MAINTENANCE
- LABORATORY & FIELD TESTING DATA

## Design and Operation

### Basic Operation

The Vortechs® Stormwater Treatment System is a hydrodynamic separator designed to enhance gravitational separation of floating and settling materials from stormwater flows. Stormwater flows enter the unit tangentially to the grit chamber, which promotes a gentle swirling motion. As polluted water circles within the grit chamber, pollutants migrate toward the center of the unit where velocities are the lowest. The majority of settlable solids are left behind as stormwater exits the grit chamber through two apertures on the perimeter of the chamber. Next, buoyant debris and oil and grease are separated from water flowing under the baffle wall due to their relatively low specific gravity. As stormwater exits the System through the flow control wall and ultimately through the outlet pipe, it is relatively free of floating and settling pollutants.

Over time a conical pile tends to accumulate in the center of the unit containing sediment and associated metals, nutrients, hydrocarbons and other pollutants. Floating debris and oil and grease form a floating layer trapped in front of the baffle wall. Accumulation of these pollutants can easily be assessed through access manholes over each chamber. Maintenance is typically performed through the manhole over the grit chamber.

### Design Process

Each Vortechs® System is custom designed based on:

- Site size
- Site runoff coefficient
- Regional precipitation intensity distribution
- Anticipated pollutant characteristics

These factors are incorporated into the Rational Rainfall Method™, developed by Vortechnics, Inc. to estimate net annual pollutant removal efficiency.

The Rational Rainfall Method™

Differences in local climate, topography and scale make every site hydraulically unique. It is important to take these factors into consideration when estimating the long-term performance of any stormwater treatment system. To estimate efficiencies as accurately as possible, Vortechnics has developed the Rational Rainfall Method™ which combines site-specific information with laboratory generated performance data (Technical Bulletin No. 1), and local historical precipitation records.

Short duration rain gauge records from across the United States and Canada were analyzed by Vortechnics to determine the percent of the total annual rainfall that fell at a range of intensities. US stations' depths were totaled every 15 minutes or hourly and recorded in 0.01-inch increments. Depths were recorded hourly with 1 mm resolution at Canadian stations. One trend was consistent at all sites; the vast majority of precipitation fell at low intensities and high intensity storms contributed relatively little to the total annual depth.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Method. Since most sites are relatively small and highly impervious, the rational method is appropriate. Based on the flow rates calculated for each intensity, an operating rate within a proposed Vortechs® System is determined. Finally, a removal efficiency is selected for each operating rate based on anticipated pollutant characteristics and on full scale laboratory tests. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

Vortechnics typically selects the System that will provide an 80% annual TSS load reduction based on laboratory generated performance curves for 50-micron sediment particles, however the Rational Rainfall Method™ can accommodate other removal efficiency or particle size targets. It can also be used to estimate annual hydrocarbon load reductions.

Once a System size is established, the internal elements of the System will be designed based on information provided by the site engineer. Flow control sizes and shapes, sump depth, spill storage capacity, sediment storage volume and inlet and outlet orientation are determined for each System. In addition, bypass weir calculations are made for off-line Systems.

## Flow Control Calculations

### The Orifice

The lower flow control or "orifice" is typically sized to submerge the inlet pipe when the Vortechs® System is operating at 20% of its' treatment capacity. The orifice is typically a Cippoletti shaped aperture defined by its flat crest and sides which incline outwardly at a slope of 1 horizontal to 4 vertical.

Flow through orifice = $Q_{orf} = C_d * A * (2gh)^{0.5}$

Where $C_d$ = Orifice contraction coefficient = 0.56 (558.5) (based on Vortechnics laboratory testing)
$A$ = Orifice flow area, $ft^2$ ($m^2$) (calculated by Vortechnics technical staff)
$h$ = Design head, ft (m) (equal to the inlet pipe diameter)

The minimum orifice crest length is 3-inches (76 mm) and the minimum orifice height is 4-inches (102 mm). If flow must be restricted beyond what can be provided by this size aperture, a Fluidic-Amp™ hydro-brake flow control will be used. The hydro-brake allows the minimum flow constriction to remain at 3-inches (76 mm) or greater while further reducing flow due to its unique throttling action.

### The Weir

The high flow control or "weir" is sized to pass the peak System capacity minus the peak orifice flow when the water surface elevation is at the top of the weir. This flow control is also a Cippoletti type weir.

The weir flow control is sized by solving for the crest length and head in the following equation:

Flow through weir = $Q_{weir} = C_d * L * (h)^{1.5}$

Where $C_d$ = Cippoletti Weir coefficient = 3.37 (1860.5) (based on Vortechnics laboratory testing)
$h$ = Available head, ft (m) (height of weir)
$L$ = Design weir crest length, ft (m) (calculated by Vortechnics technical staff)

Bypass Calculations

In some cases, pollutant removal goals can be met without treating peak flow rates and it is most feasible to use a smaller Vortechs® System configured with an external bypass. In such cases, a bypass design is recommended by Vortechnics for each off-line System. To calculate the bypass capacity, first subtract the System's treatment capacity from the peak conveyance capacity of the collection system (minimum of 10 year recurrence interval). The result is the flow rate that must be bypassed to avoid surcharging the Vortechs® System. Then use the following arrangement of the Francis formula to calculate the depth of flow over the bypass weir.

Flow over bypass weir = $H = (Q_{bypass} / (C_d * L))^{2/3}$

Where $C_d$ = Discharge Coefficient = 3.3 (1838.5) for rectangular weir
$H$ = Depth of flow over bypass weir crest, ft (m)
$L$ = Length of bypass weir crest, ft (m)

The bypass weir crest elevation is then calculated to be the elevation at the top of the Cippoletti weir minus the depth of flow.

**Hydraulic Capacity**

In the event that the peak design flow from the site is exceeded, it is important that the Vortechs® System is not a constriction to runoff leaving the site. Therefore, each System is designed with enough hydraulic capacity to pass the 100-year flow rate. It is important to note that at operating rates above 100 gpm/ft$^2$ (4074 lpm/m$^2$) of the grit chamber area (peak *treatment* capacity), captured pollutants may be lost.

When the System is operating at peak *hydraulic* capacity, water will be flowing through the gap over the top of the flow control wall as well as the orifice and the weir.

## MAINTENANCE

The Vortechs® System should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the System collects pollutants will depend more heavily on site activities than the size of the unit, e.g., unstable soils or heavy winter sanding will cause the grit chamber to fill more quickly but regular sweeping will slow accumulation.

**Inspection**

Inspection is the key to effective maintenance and is easily performed. Vortechnics recommends ongoing quarterly inspections of the accumulated sediment. Pollutant deposition and transport may vary from year to year and quarterly inspections will help insure that Systems are cleaned out at the appropriate time. Inspections should be performed more often in the winter months in climates where sanding operations may lead to rapid accumulations, or in equipment washdown areas. It is very useful to keep a record of each inspection. A simple form for doing so is provided.

The Vortechs® System should be cleaned when inspection reveals that the sediment depth has accumulated to within six inches (152 mm) of the dry-weather water surface elevation. This determination can be made by taking 2 measurements with a stadia rod or similar measuring device; one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. The System should be cleaned out if the difference between the two measurements is six inches (152 mm) or less. Note: to avoid underestimating the volume of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Finer, silty particles at the top of the pile typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile.

## Cleaning

Maintaining the Vortechs® System is easiest when there is no flow entering the System. For this reason, it is a good idea to schedule the cleanout during dry weather. Cleanout of the Vortechs® System with a vacuum truck is generally the most effective and convenient method of excavating pollutants from the System. If such a truck is not available, a "clamshell" grab may be used, but it is difficult to remove all accumulated pollutants with such devices.

In Vortechs® installations where the risk of large petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, an oil or gasoline spill should be cleaned out immediately. Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use adsorbent pads since they are usually cheaper to dispose of than the oil water emulsion that may be created by vacuuming the oily layer. Trash can be netted out if you wish to separate it from the other pollutants.

Accumulated sediment is typically evacuated through the manhole over the grit chamber. Simply remove the cover and insert the vacuum hose into the grit chamber. As water is evacuated, the water level outside of the grit chamber will drop to the same level as the crest of the lower aperture of the grit chamber. It will not drop below this level due to the fact that the bottom and sides of the grit chamber are sealed to the tank floor and walls. This "Water Lock" feature prevents water from migrating into the grit chamber, exposing the bottom of the baffle wall. Floating pollutants will decant into the grit chamber as the water level there is drawn down. This allows most floating material to be withdrawn from the same access point above the grit chamber.

If maintenance is not performed as recommended, sediment may accumulate outside the grit chamber. If this is the case, it may be necessary to pump out all chambers. It is a good idea to check for accumulation in all chambers during each maintenance event to prevent sediment build up there.

Manhole covers should be securely seated following cleaning activities, to ensure that surface runoff does not leak into the unit from above.

# INSPECTION & MAINTENANCE LOG

| Model: 5000 | | | Location: Anywhere, USA | | |
|---|---|---|---|---|---|
| Date | Water Depth to Sediment[1] | Floatable Layer Thickness[2] | Maintenance Performed | Maintenance Personnel | Comments |
| 12/01/99 | 36" (914 mm) | 0" | N/A | B. Johnson | Installed |
| 03/01/00 | 28" (711 mm) | Sheen | None | B. Johnson | Swept parking lot |
| 09/01/00 | 20" (508 mm) | 1" (25.4 mm) | Sorbent pads deployed to remove captured oil | S. Riley | Oil spill |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
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SAMPLE

1. The water depth to sediment is determined by taking two measurements with a stadia rod: one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. When the difference between the two measurements is six inches (152 mm) or less, the System should be cleaned out.

2. For optimum performance, the System should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of a spill, the System should be cleaned immediately.

Vortechs® Stormwater Treatment System

# INSPECTION & MAINTENANCE LOG

| **Model:** | | | **Location:** | | |
|---|---|---|---|---|---|
| **Date** | **Water Depth to Sediment[1]** | **Floatable Layer Thickness [2]** | **Maintenance Performed** | **Maintenance Personnel** | **Comments** |
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| | | | | | |

1. The water depth to sediment is determined by taking two measurements with a stadia rod: one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. When the difference between the two measurements is six inches (152 mm) or less, the System should be cleaned out.

2. For optimum performance, the System should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of a spill, the System should be cleaned immediately.

LABORATORY AND FIELD TESTING

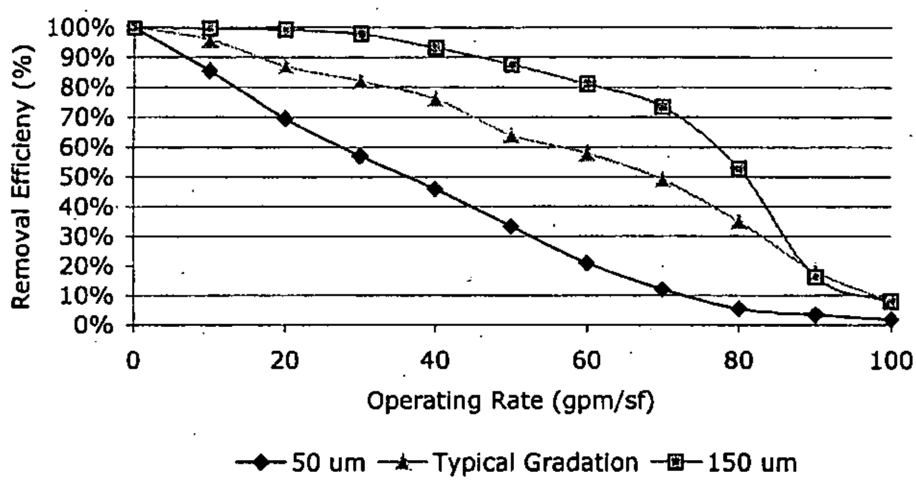
## Introduction

Vortechnics is an established leader in the stormwater treatment industry, marketing the Vortechs® Stormwater Treatment System as a technology capable of removing a high percentage of floating and settling pollutants from stormwater flows. Extensive testing in both the laboratory and in the field has produced a comprehensive set of data describing the relationship between flow rate, particle size, and removal efficiency.

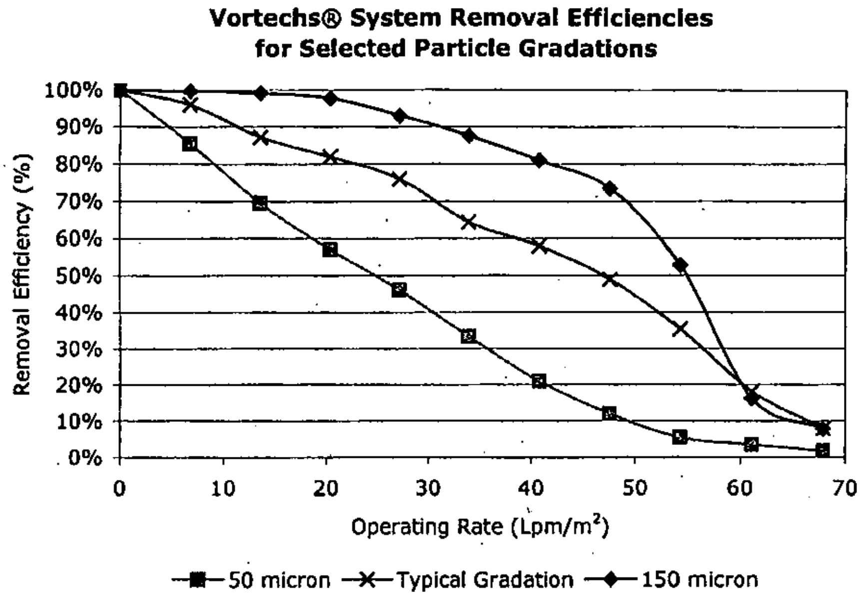
Sections 1 and 2 contain the results of laboratory and field-testing. Section 1 shows the results of full-scale testing with a Vortechs® Model 2000 at Vortechnics' laboratory in Portland, Maine. Section 2 includes long term monitoring results from several Vortechs® Systems installed on typical projects.

## Laboratory Testing - Vortechs® Stormwater Treatment System Performance

**Vortechs® System Removal Efficiencies for Selected Particle Gradations**




- See Table 1




- See Table 1

These performance curves are based on laboratory tests using a full scale Vortechs® System Model 2000. The testing protocol used is described on the following pages. The 150-micron curve demonstrates the results of tests using particles that passed through a 100-mesh sieve and were retained on a 150-mesh sieve. The 50-micron curve is based on tests of particles passing through a 200-mesh sieve and retained on a 400-mesh sieve. A slurry representing an average stormwater sediment gradation, with the particle size gradation shown in Table 1, was also tested in our laboratory.

As the graph clearly shows, Vortechs® Systems maintain positive total suspended solids (TSS) removal efficiencies over the full range of operating rates, allowing the System to effectively treat all runoff from large infrequent design storms as well as runoff from the more frequent low intensity storms. Precast Vortechs® Systems are designed to treat peak flows from 1.6 cfs (0.045 cms) up to 25 cfs (0.707 cms) without bypassing. Peak flows that exceed rated treatment capacities can be conveyed around the System with an external bypass. Internal bypasses can be configured to direct low flows from the last chamber of the Vortechs® System to polishing treatment when more stringent water quality standards are imposed. In all configurations, high removal efficiencies are achieved during the lower intensity storms; which constitute the majority of annual rainfall volume.

**Laboratory Quality Control Brief**

The following protocol summarizes standard operating procedures for Total Suspended Solids (TSS) testing in the Vortechnics Laboratory. These guidelines were followed in the creation of the preceding performance curves.

Sediment Source

Sediment samples are sorted according to ASTM Special Technical Publication 477 B, which establishes sieve analysis procedures. U.S. Standard Sieves in a Gilson SS-15 sieve shaker are used to separate particles to the various fractions required for our tests. To ensure uniformity of those fractions, an unsorted sample is sieved until less than 1% of that sample passes through the sieve in one minute. All sediment recovered after a test is dried and resieved before reuse. Unless otherwise specified, mineral sediments with a density of 2.65 $g/cm^3$ are used.

The following table describes the particle size distribution of samples tested by Vortechnics to represent TSS Loading in typical urban runoff.

**Table 1**

| **Particle Size Distribution** | **Percentage of Sample Make-up** |
|---|---|
| < 63 µm | 42% |
| 63 - 75 µm | 4% |
| 75 - 100 µm | 9% |
| 100 - 150 µm | 7% |
| 150 - 250 µm | 11% |
| > 250 µm | 27% |

Flow Calibration and Regulation

Flow calibration is accomplished by calculating the head at the baffle wall required to produce a given flow rate through the orifice and the weir in the flow control wall. Flow is regulated by a 12-inch (305 mm) butterfly valve located upstream of the Vortechs® System. In order to simulate field conditions, flow rates are changed gradually to avoid flow surges through the System. The test flow rate is set by observing the head in the Vortechs® System and adjusting the regulating valve accordingly. Before any samples are collected, the valve must remain fixed for a period equal to half of the detention time so that flow equalizes throughout the System. Each test group is planned so that flow rates increase incrementally in consecutive tests.

Sediment Metering

All sediment is injected into the inlet pipe via a ¼-inch (6.35 mm) flexible hose using a Watson Marlow 5058 peristaltic metering pump. For TSS tests, a known gradation of sediment and water are combined in approximately a 1/2 pound/gallon (0.06 kg/L) ratio in a holding tank and homogenized by a mixing propeller powered by a 1/3 horsepower (246 W) motor. The mixer is activated at least 5 minutes before testing commences and runs continuously throughout the test. The metering pump is activated for a period of time equal to at least half of the detention time of the Vortechs® System at the test flow rate, before the first influent sample is taken. The pump must run continuously until the last effluent sample is taken.

Sample Collection
All influent samples are taken from a 6-inch (152 mm) gate valve located upstream of the Vortechs® System. A collection bin housing a 500 mL sample container is positioned beneath the valve. Five seconds before each sample is taken the valve is quickly opened and closed to eliminate any interference from particles that have settled in the low velocity region of the gate. This eliminates artificially high influent readings. The time that the influent sample was taken is recorded and the corresponding effluent sample is collected after a period of time equal to the detention time. Effluent grab samples are collected at the discharge pipe, by sweeping the mouth of a 500 mL bottle through the exiting flow stream. Samples are annotated and refrigerated until they can be analyzed.

Sample Analysis
TSS samples are analyzed in the Vortechnics laboratory, following EPA method 160.2, a method for the measurement of total non-filterable solids. Volume measurements are accurate to 0.6 mL using a 500 mL graduated cylinder and an Acculab V-1 analytical balance with a readability of 0.001 g is used to measure mass.

**Field Testing - Vortechs® System Field Monitoring Summary**

Vortechnics has become a leader in the stormwater industry in large part because of the company's unwavering long-term commitment to research and development. In addition to performing their own field tests, Vortechnics has diligently pursued opportunities to work with third party organizations to test their products. In fact, the Vortechs® System has been subjected to the most comprehensive third party testing in the industry. These independent studies have allowed Vortechnics to corroborate their lab and field data to ensure that actual performance of the Vortechs® System matches their claims.

**Following are brief summaries of the field tests completed to date. Please contact Vortechnics for the full reports. In addition, all reports are available for download on Vortechnics website at www.vortechnics.com.**

DeLorme Mapping Company - Yarmouth, ME
Vortechnics, Inc.

Prior to this premier field test of the Vortechs® System, Vortechnics developed an extensive body of laboratory data to document total suspended solids (TSS) removal efficiency. Vortechnics performed this field study in order to compare the performance predicted using laboratory data to the performance of a correctly sized System in the field.

The study site was the headquarters of DeLorme Mapping in Yarmouth, Maine. The building, driveway, parking lot and ancillary facilities were constructed in 1996. A Vortechs® Model 11000 was installed to treat runoff from the 300-space, 4-acre (1.62 ha) parking lot.

| | |
|---|---|
| Testing Period | May 1999 to Dec. 1999 |
| # of Storms Sampled | 20 |
| Mean Influent Concentration | 328 mg/L |
| Mean Effluent Concentration | 60 mg/L |
| Removal Efficiency | 82% |

The main purpose of the DeLorme study was to verify that the sizing methodology developed from our full-scale laboratory testing was valid and an accurate means of predicting field performance. The results of the study confirmed our sizing methodology.

**Village Marine Drainage - Lake George, NY**
**New York State Department of Environmental Conservation, Division of Water**

The New York State DEC used funds obtained in a Section 319 grant to initiate a study of the effectiveness of the Vortechs® System to remove sediment and other pollutants transported by stormwater to Lake George, Lake George Village, New York. "Since the 1970s, when there was a rapid increase in the rate and concentration of development along the southwestern shores of Lake George, we have been concerned about the impact of stormwater discharges into the lake," said Tracy West, co-author of the study.

| | |
|---|---|
| Testing Period | Feb. 2000 to Dec. 2000 |
| # of Storms Sampled | 13 |
| Mean Influent Concentration | 801 mg/L |
| Mean Effluent Concentration | 105 mg/L |
| Removal Efficiency | 88% |

The study concluded that the Village and Town of Lake George should consider installing additional Vortechs® Systems in areas where sedimentation and erosion have been identified as non-point source pollution problems.

**Harding Township Rest Area - Harding Township, NJ**
**RTP Environmental Associates**

This third party evaluation was performed under a U.S. Environmental Protection Agency grant, administered by the New Jersey Department of Environmental Protection. A. Roger Greenway, principal of RTP Environmental Associates, Inc., conducted the study in conjunction with Thonet Associates, which assisted with data analysis and helped develop best management practices (BMP) recommendations.

The Vortechs® Model 4000 was sized to handle a 100-year storm from the 3-acre (1.21 ha) paved parking area at the Harding Rest Stop, located off the northbound lane of I-287 in Harding Township, New Jersey.

| | |
|---|---|
| Testing Period | May 1999 to Nov. 2000 |
| # of Storms Sampled | 5 |
| Mean Influent Concentration (TSS) | 493 mg/L |
| Mean Effluent Concentration (TSS) | 35 mg/L |
| Removal Efficiency (TSS) | 93% |
| Mean Influent Concentration (TPH) | 16 mg/L |
| Mean Effluent Concentration (TPH) | 5 mg/L |
| Removal Efficiency (TPH) | 67% |

The study concluded that truck rest stops and similar parking areas would benefit from installing stormwater treatment systems to mitigate the water quality impacts associated with stormwater runoff from these sites.

**Timothy Edwards Middle School - South Windsor, CT**
**UCONN Department of Civil & Environmental Engineering**

Susan Mary Board published this most recent study of the Vortechs® System as a thesis as part of the requirements for a Master of Science degree from the University of Connecticut. Her objective was to determine how well the Vortechs® System retained pollutants from parking lot runoff, including total suspended solids (TSS), nutrients, metals, and petroleum hydrocarbons.

A Vortechs® Model 5000 was installed in 1998 to treat runoff from the 82-space parking lot of Timothy Edwards Middle School. The entire watershed was approximately 2-acres (0.81 ha), and was 80% impervious.

| | |
|---|---|
| Testing Period | July 2000 to April 2001 |
| # of Storms Sampled | weekly composite samples taken |
| Mean Influent Concentration | 324 mg/L |
| Mean Effluent Concentration | 73 mg/L |
| Removal Efficiency | 77% |

Additionally, the Vortechs® System was particularly effective in removing zinc (85%), lead (46%), copper (56%), phosphorus (67%) and nitrate (54%).

The study concluded that the Vortechs® Stormwater Treatment System significantly reduced effluent concentrations of many pollutants in stormwater runoff.

# APPENDIX E

## StormTrap Detention System:
## Water Quality Treatment Capacities, Details, and Notes

## [Detention Vault]

June 29, 2005

Brendan Hastie
Rick Engineering
19 Technology Dr
Irvine, CA 92618

RE: County of San Diego - San Diego, CA
PROJECT: CH-0938-CA-05

Dear Brendan:

StormTrap, LLC is pleased to offer the following budget estimate for the installation of the StormTrap System for the above stated project. Please note that the estimate assumes that all spoil will be left on site and is exclusive of any applicable taxes. ***Assumptions used for this project are as follows (see page 2 of the design for complete design critera): Cover: 6" (Max of 20'-0"); Groundwater: below system; Loading ASTM C857 HS-20.***

*
**5'-0" SINGLETRAP**
Total Water Storage Provided: 0.15 Acre-Feet or 6,523 C.F.

STORMTRAP MATERIAL COST
28 StormTrap Units (see attached layout)

| | |
|---|---|
| SUB TOTAL FOR MATERIAL AND FREIGHT: | **$158,108.00** |
| EXCAVATION<br>1,174 C.Y. @ $10.00 PER C.Y. | $11,740.00 |
| INSTALL STORMTRAP UNITS<br>56 PIECES @ $300.00 PER PIECE | $16,800.00 |
| STONE<br>27 C.Y. @ $30.00 PER C.Y. | $810.00 |
| BACKFILL<br>556 C.Y. @ $30.00 PER C.Y. | $16,680.00 |
| SUB-TOTAL FOR INSTALLATION: | **$46,030.00** |
| TOTAL BUDGET ESTIMATE<br>FOR MATERIAL AND INSTALLATION | **$204,138.00** |

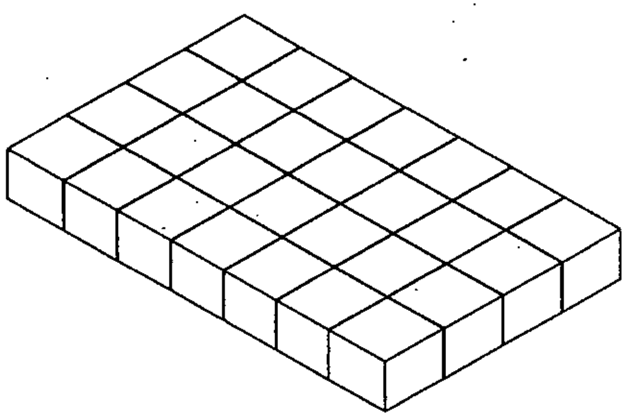
Please feel free to call me if you have any questions.

Sincerely,

Cole Herron

StormTrap™

PRECAST CONCRETE MODULAR STORM WATER DETENTION



COUNTY OF SAN DIEGO
SAN DIEGO, CA

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| 7 | STANDARD - 5'-0" SINGLETRAP TYPE IV | 1 |
| 8 | STANDARD - 5'-0" SINGLETRAP TYPE V | 1 |
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| JOB SITE INFORMATION | |
|---|---|
| DESCRIPTION | |
| JOB NAME: | COUNTY OF SAN DIEGO |
| JOB ADDRESS: | SAN DIEGO, CA |
| ENGINEERING CO: | RICK ENGINEERING |
| CONTACT NAME: | BRENDAN HASTIE |
| CONTACT PHONE: | 619-291-0707 |
| CONTACT FAX: | 619-291-4165 |
| STORM TRAP SUPPLIER: | STORMTRAP |
| CONTACT NAME: | COLE HERRON |
| CONTACT PHONE: | 815-941-4663 |
| CONTACT FAX: | 815-416-1100 |
| WATER STORAGE REQ'D: | CUBIC FEET |
| WATER STORAGE PROV: | 6523 CUBIC FEET |
| UNIT HEADROOM: | 5'-0" SINGLETRAP |
| UNIT QUANTITY: | 26 UNITS - 26 TOTAL PIECES |

StormTrap

P.O. BOX 782
MORRIS, IL 60450
1-87-STORMTRAP

ENGINEER INFORMATION:

RICK ENGINEERING

19 TECHNOLOGY DR
IRVINE, CA
Phone: 619-291-0707
Fax: 619-291-4165

PROJECT INFORMATION:

COUNTY OF SAN DIEGO
SAN DIEGO, CA
CH-0938-CA-05

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## STORMTRAP INSTALLATION SPECIFICATION

1. STORMTRAP MODULES SHALL BE MANUFACTURED ACCORDING TO SHOP DRAWINGS APPROVED BY THE INSTALLING CONTRACTOR AND ENGINEER. THE SHOP DRAWINGS SHALL INDICATE SIZE AND LOCATION OF ROOF OPENINGS AND INLET/ OUTLET PIPE OPENINGS.

2. STORMTRAP SHALL BE INSTALLED IN ACCORDANCE WITH ASTM C891-90, STANDARD PRACTICE FOR INSTALLATION OF UNDERGROUND PRE-CAST CONCRETE UTILITY STRUCTURES. THE FOLLOWING ADDITIONS AND/OR EXCEPTIONS SHALL APPLY:

   A. SPECIFICATIONS ON THE ENGINEERS DRAWINGS SHALL TAKE PRECEDENT.

   B. STORMTRAP MODULES SHALL BE PLACED ON LEVEL FOUNDATION (SEE DETAIL "A") WITH A 1'-0" OVERHANG ON ALL SIDES THAT SHALL BE POURED IN A PLACE BY INSTALLING CONTRACTOR.

   C. THE STORMTRAP MODULES SHALL BE PLACED SUCH THAT THE MAXINUM SPACE BETWEEN ADJACENT MODULES DOES NOT EXCEED 3/4". IF THE SPACE EXCEEDS 3/4", THE MODULES SHALL BE RESET WITH APPROPRIATE ADJUSTMENT MADE TO LINE AND GRADE TO BRING THE SPACE INTO SPECIFICATION.

   D. THE PERIMETER HORIZONTAL JOINT OF THE STORMTRAP MODULES SHALL BE SEALED TO THE FOOTINGS WITH PREFORMED MASTIC JOINT SEALER ACCORDING TO ASTM C891-90, 6.8 AND 8.12.

   E. ALL EXTERIOR JOINTS BETWEEN ADJACENT STORMTRAP MODULES SHALL BE SEALED WITH 1'-0" EXTERNAL SEALING BANDS CONFORMING TO ASTM C891-90 AND SHALL BE 1'-0" RUBBER BUTYL SEALANT AS APPROVED BY STORMTRAP. THE JOINT WRAP BUTYL EXTERIOR WRAP SHALL BE INSTALLED ACCORDING TO THE FOLLOWING INSTALLATION INSTRUCTIONS:

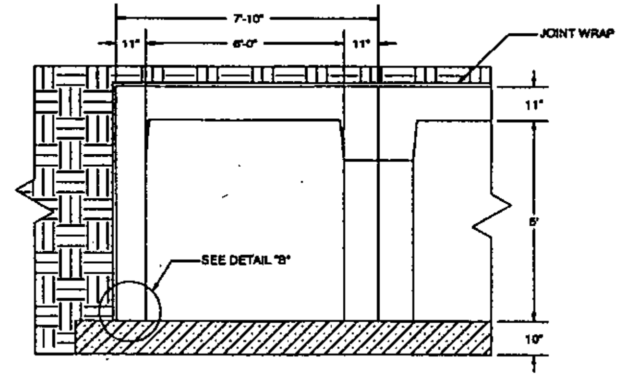
      1. USE A BRUSH OR WET CLOTH TO THOROUGHLY CLEAN THE OUTSIDE SURFACE AT THE POINT WHERE THE JOINT WRAP IS TO BE APPLIED.

      2. A RELEASE PAPER PROTECTS THE BUTYL SEALANT SIDE OF THE JOINT WRAP. WRAP THE BUTYL TAPE (BUTYL SIDE DOWN) AROUND THE STRUCTURE, REMOVING THE RELEASE PAPER AS YOU GO. PRESS THE JOINT WRAP FIRMLY AGAINST THE STORMTRAP MODULE SURFACE WHEN APPLYING.

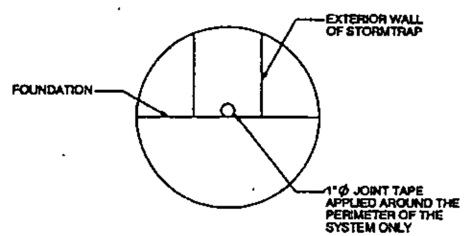
   F. THE FILL PLACED AROUND THE STORMTRAP UNITS MUST BE DEPOSITED ON BOTH SIDES AT THE SAME TIME AND TO APPROXIMATELY THE SAME ELEVATION. AT NO TIME SHALL THE FILL BEHIND ONE SIDE WALL BE MORE THAN 2'-0" HIGHER THAN THE FILL ON THE OPPOSITE SIDE. CARE SHALL BE TAKEN TO PREVENT ANY WEDGING ACTION AGAINST THE STRUCTURE, AND ALL SLOPES BOUNDING OR WITHIN THE AREA TO BE BACK FILLED MUST BE STEPPED OR SERRATED TO PREVENT WEDGE ACTION. (REFERENCE ARTICLE 502.10 I.D.O.T. S.S.R.B.C.) CARE SHALL ALSO BE TAKEN AS NOT TO DISRUPT THE JOINT WRAP FROM THE JOINT DURING THE BACK FILL PROCESS.

## STORMTRAP SPECIFICATION

1. CONCRETE: 6,000 p.s.i. @ 28 DAYS, 5%-8% ENTRAINED AIR, 4" MAX. SLUMP.
2. REBAR: ASTM A-615 GRADE 60.
3. DESIGN CRITERIA:
   A. ASTM C858
   B. LOADING PER ASTM C857, INCLUDING:
      1. TOTAL COVER: MIN. 6" MAX. 20'-0"
      2. CONCRETE CHAMBER DESIGNED FOR AASHTO HS-20 WHEEL LOAD & APPLICABLE IMPACT.
      3. VERTICAL & LATERAL SOIL PRESSURES DETERMINED USING
         - GROUNDWATER AT 9'-0" BELOW GRADE.
         - REINFORCING COVER PER ACI 318.
4. STORMTRAP IS NOT WATERTIGHT - PLEASE ADVISE IF A WATERTIGHT SOLUTION IS NEEDED

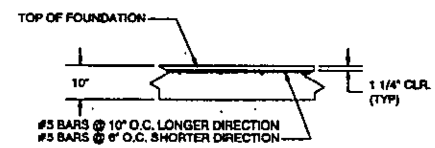



5'-0" SINGLETRAP




DETAIL "B"

JOINT TAPE INSTALLATION




DETAIL "A"

STORM TRAP FOUNDATION

NOTES:
1. 4,000 p.s.i. @ 28 DAYS, 5%-8% ENTRAINED AIR, 4" MAX. SLUMP.
2. NET ALLOWABLE SOIL PRESSURE GREATER THAN OR EQUAL TO 2,000 p.s.f.
3. SOIL CONDITIONS TO BE VERIFIED ON SITE BY OTHERS.
4. 1'-0" OVERHANG AROUND OUTSIDE OF SYSTEM.
5. 4,000 p.s.i. MUST BE REACHED BEFORE STORMTRAP UNITS CAN BE INSTALLED.

STORMTRAP


P.O. BOX 782
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IRVINE, CA
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PROJECT INFORMATION:

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DOUBLE TRAP INSTALLATION SPECIFICATIONS

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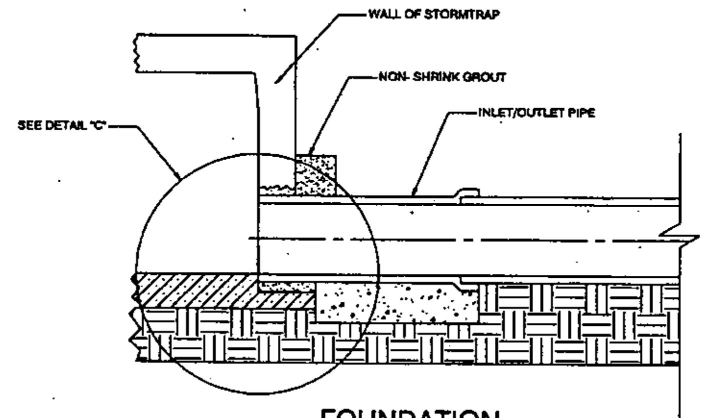
02

## RECOMMENDED PIPE/RISER SPECIFICATION

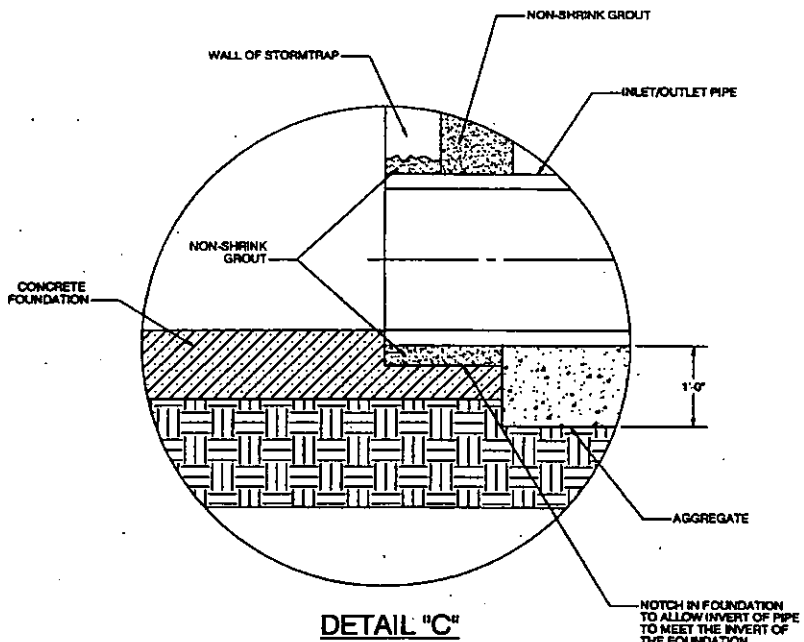
1. CONNECTING PIPES SHALL BE INSTALLED WITH A 1'-0" CONCRETE COLLAR, AND A CONCRETE CRADLE FOR AT LEAST ONE PIPE LENGTH, AS SHOWN. A STRUCTURAL GRADE CONCRETE OR GROUT WITH A MINIMUM 28 DAY COMPRESSIVE STRENGTH OF 3000 p.s.i. SHALL BE USED.
2. THE ANNULAR SPACE BETWEEN THE PIPE AND THE HOLE SHALL BE FILLED WITH NON-SHRINK GROUT.

## RECOMMENDED INSTALLATION INSTRUCTIONS

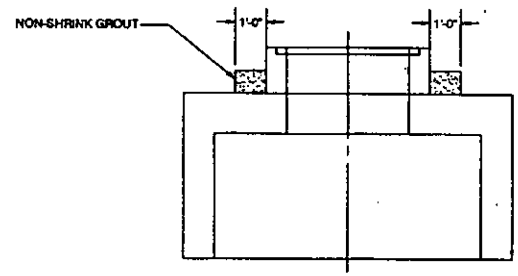
1. CLEAN AND LIGHTLY LUBRICATE ALL OF PIPE TO BE INSETED INTO STORMTRAP.
2. IF PIPE IS CUT, CARE SHOULD BE TAKEN TO ALLOW NO SHARP EDGES. BEVEL AND LUBRICATE LEAD END OF PIPE.
3. ALIGN CENTER OF PIPE TO CORRECT ELEVATION AND INSERT INTO OPENING.




FOUNDATION PIPE CONNECTION




DETAIL "C"
CONNECTION DETAIL
(NOT TO SCALE)




RISER DETAIL

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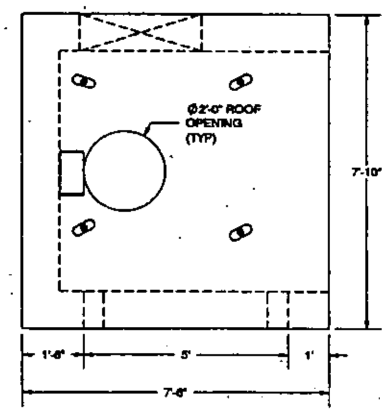
SHEET NUMBER: 2.1

## RECOMMENDED ACCESS OPENING SPECIFICATION

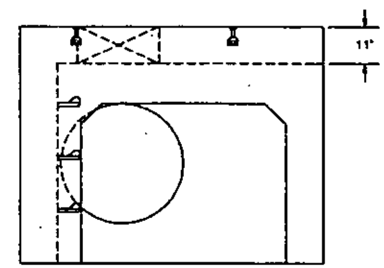
1. A TYPICAL ACCESS OPENING FOR THE STORMTRAP SYSTEM RANGES FROM 2'-0" TO 3'-0" IN DIAMETER. HOWEVER, STORMTRAP IS CAPABLE OF HAVING OPENINGS LARGER THAN 3'-0" IN DIAMETER.
2. PLASTIC COASTED STEEL STEPS PRODUCED BY M.A. INDUSTRIES PART #PS3-PFC (SEE DETAIL TO THE RIGHT) ARE TO BE PLACED INSIDE ANY UNIT WHERE DEEMED NECESSARY. THE HIGHEST STEP IN THE UNIT IS TO BE PLACED A DISTANCE OF 1'-0" FROM THE INSIDE EDGE OF THE STORMTRAP UNITS. ALL ENSUING STEPS SHALL BE PLACE WITH A MINIMUM DISTANCE OF 1'-4" BETWEEN THEM. STEPS MAY BE MOVED OR ALTERED TO AVOID OPENINGS OR OTHER IRREGULARITIES IN THE UNIT.
3. STORMTRAP LIFTING INSERTS MAY BE RELOCATED TO COINCIDE WITH THE ACCESS OPENING OR THE CENTER OF GRAVITY OF THE UNIT AS NEEDED.
4. STORMTRAP ACCESS OPENINGS MAY NOT INTERFERE WITH WITH INLET AND/OR OUTLET OPENINGS.
5. STORMTRAP ACCESS OPENINGS MAY NOT EXCEED A DISTANCE OF 50'-0" INBETWEEN WITHOUT A CONSECUTIVE CORRESPONDING ACCESS OPENING.

## RECOMMENDED PIPE OPENING SPECIFICATION

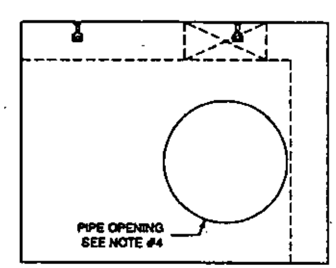
1. MINIMUM EDGE DISTANCE FOR AN OPENING ON THE OUTSIDE WALL SHALL BE NO LESS THAN 1'-0".
2. MINIMUM DISTANCE FROM THE BASE OF THE ROOF SLAB SHALL BE NO LESS THAN 1'-0".
3. ALL OPENINGS MUST RETAIN AT LEAST 1'-0" OF CLEARANCE IN ALL DIRECTIONS FROM THE EDGE OF THE STORMTRAP UNITS.
4. OPENING SIZE SHALL NOT EXCEED Ø26" OR 1'-6" LESS THEN THE INSIDE HEIGHT OF THE UNIT. EXAMPLE: 3'-0" UNIT MAXIMUM OPENING = Ø1'-6".
5. OPENINGS ARE NOT LIMITED TO THE ABOVE PARAMETERS BUT ARE RECOMMENDED. ANY OPENING NEEDED THAT DOES NOT FIT THE CRITERIA SHALL BE BROUGHT TO THE ATTENTION OF STORMTRAP FOR REVIEW.



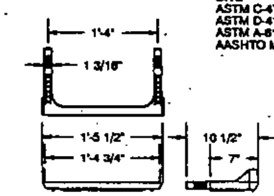

PLAN VIEW




ELEVATION VIEW

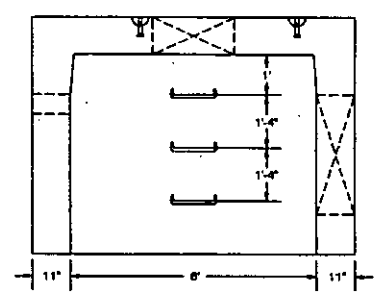



OUTSIDE WALL




MEETS:
OPSS 1351.08.02
BNQ
ASTM C-478-95a
ASTM D-4101-95b
ASTM A-615
AASHTO M-199

STAIR DETAIL




SIDE VIEW


STORMTRAP
P.O. BOX 782
MORRIS, IL 60450
1-87-STORMTRAP


ENGINEER INFORMATION:


RICK ENGINEERING
19 TECHNOLOGY DR
IRVINE, CA
Phone: 619-291-0707
Fax: 619-291-4165


PROJECT INFORMATION:

COUNTY OF SAN DIEGO
SAN DIEGO, CA
CH-0938-CA-05

CURRENT ISSUE DATE: 06/29/05

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SCALE: NTS

SHEET TITLE: SINGLE TRAP INSTALLATION SPECIFICATIONS

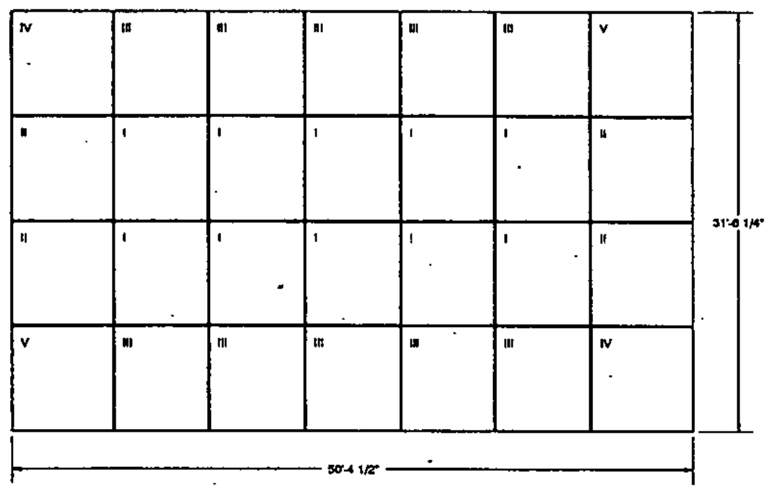
SHEET NUMBER: 2.2

## BILL OF MATERIALS

| QTY. | PART NO. | DESCRIPTION |
|---|---|---|
| 10 | TYPE I | 5'-0" SINGLETRAP TYPE I |
| 4 | TYPE II | 5'-0" SINGLETRAP TYPE II |
| 10 | TYPE III | 5'-0" SINGLETRAP TYPE III |
| 2 | TYPE IV | 5'-0" SINGLETRAP TYPE IV |
| 2 | TYPE V | 5'-0" SINGLETRAP TYPE V |
| 15 | JOINT TAPE | JOINT TAPE - 14.5' PER ROLL |
| 5 | JOINT WRAP | JOINT WRAP - 150' PER ROLL |

NOTES:

1. DIMENSION OF STORMTRAP SYSTEM ALLOW FOR A 3/4" GAP BETWEEN EACH UNIT.
2. ALL DIMENSIONS TO BE VERIFIED IN THE FIELD BY OTHERS.




5'-0" SINGLETRAP UNITS
6523 C.F. OF STORAGE
SEE SHEET 2 FOR INSTALLATION SPECIFICATIONS

LAYOUT DETAIL

STORMTRAP
P.O. BOX 782
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1-87-STORMTRAP

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SCALE:
NTS

SHEET TITLE:
LAYOUT DETAIL

SHEET NUMBER:
03


CONCRETE
FOUNDATION PLAN

NOTES:

1. DIMENSION OF FOUNDATION MUST HAVE 1'-0" OVERHANG BEYOND EXTERNAL FACE OF UNITS.
2. DIMENSION OF STORMTRAP SYSTEM ALLOW FOR A 3/4" GAP BETWEEN EACH UNIT.
3. ALL DIMENSIONS TO BE VERIFIED IN THE FIELD BY OTHERS.
4. SEE SHEET 2 FOR INSTALLATION SPECIFICATIONS.

STORMTRAP
P.O. BOX 782
MORRIS, IL 60450
1-87-STORMTRAP

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SCALE:
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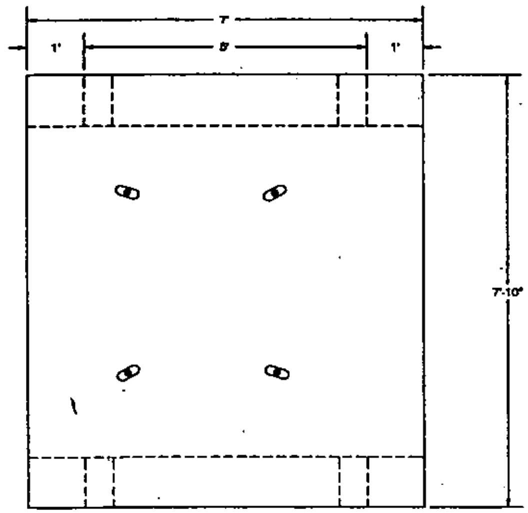
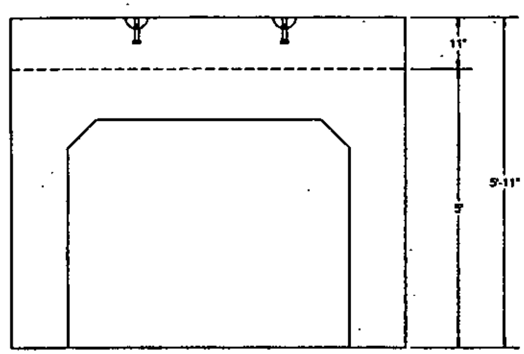
SHEET TITLE:
SINGLE TRAP INSTALLATION SPECIFICATIONS

SHEET NUMBER:
3.1

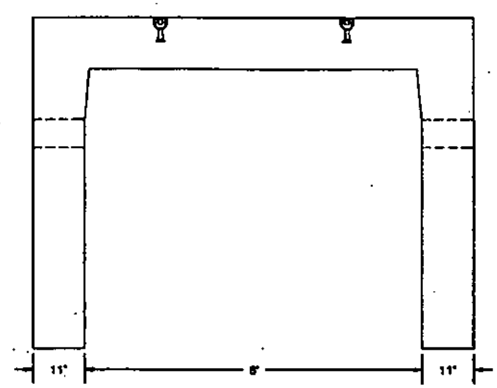



PLAN VIEW

| TYPE I UNITS | | |
|---|---|---|
| UNIT HEIGHT (in.) | CUBIC STORAGE (C.F.) | WEIGHT TOP (lbs.) |
| 60 | 245.7 | 11865 |




ELEVATION VIEW




SIDE VIEW

STORMTRAP
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SCALE:
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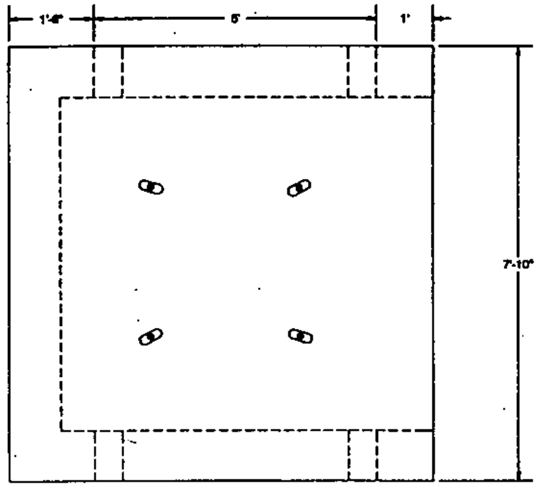
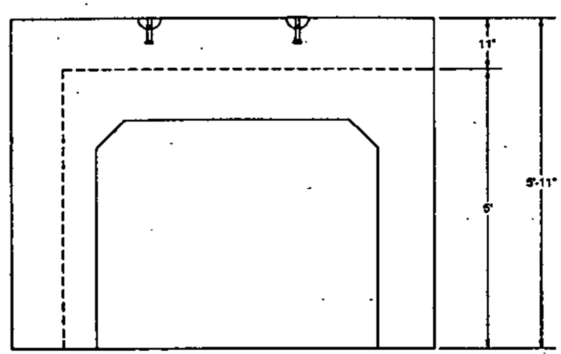
SHEET TITLE:
STANDARD
5'-0" SINGLETRAP
TYPE I

SHEET NUMBER:
04

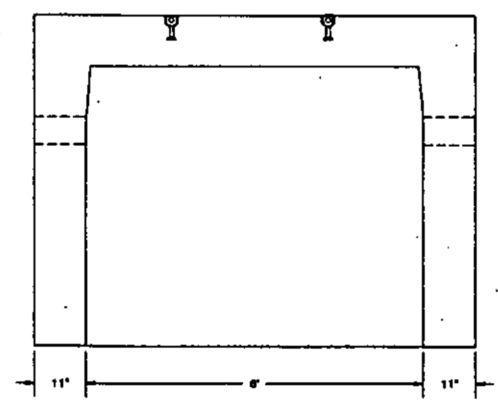



PLAN VIEW

| TYPE II UNITS | | |
|---|---|---|
| UNIT HEIGHT (in.) | CUBIC STORAGE (C.F.) | WEIGHT TOP (lbs.) |
| 60 | 232.9 | 17265 |




ELEVATION VIEW




SIDE VIEW

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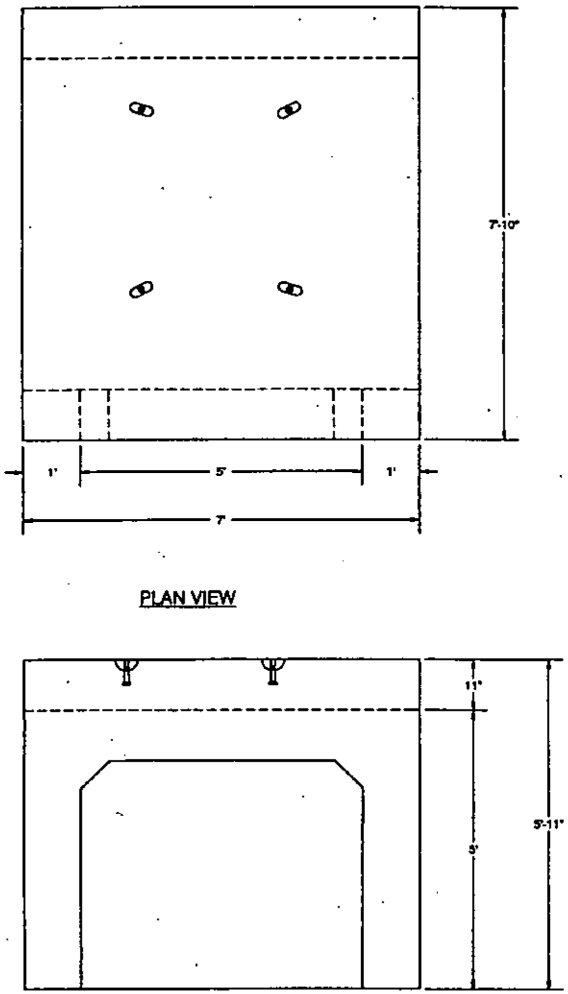
SCALE:
NTS

SHEET TITLE:
STANDARD
5'-0" SINGLETRAP
TYPE II

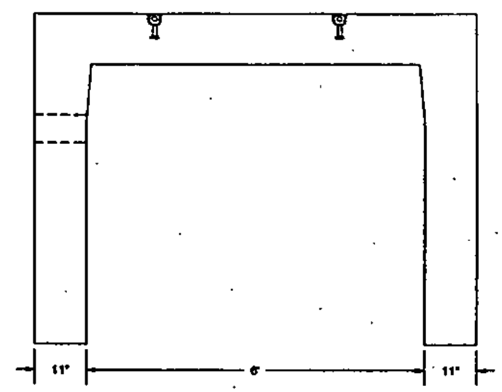
SHEET NUMBER:
05




PLAN VIEW

ELEVATION VIEW

| TYPE III UNITS | | |
|---|---|---|
| UNIT HEIGHT (in.) | CUBIC STORAGE (C.F.) | WEIGHT TOP (lbs.) |
| 60 | 227.5 | 14590 |




SIDE VIEW

STORMTRAP
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MORRIS, IL 60450
1-87-STORMTRAP

ENGINEER INFORMATION:
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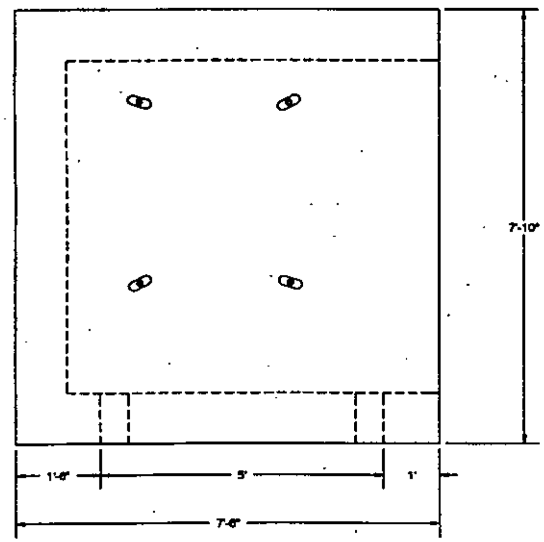
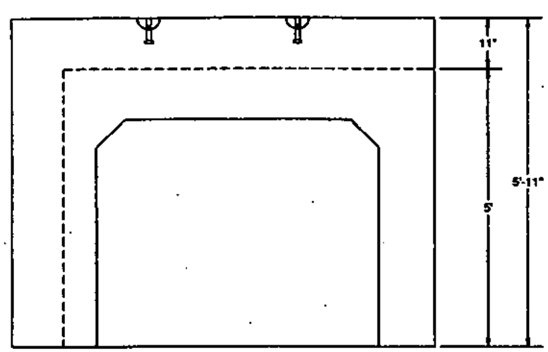
SCALE:
NTS

SHEET TITLE:
STANDARD
5'-0" SINGLETRAP
TYPE III

SHEET NUMBER:
06



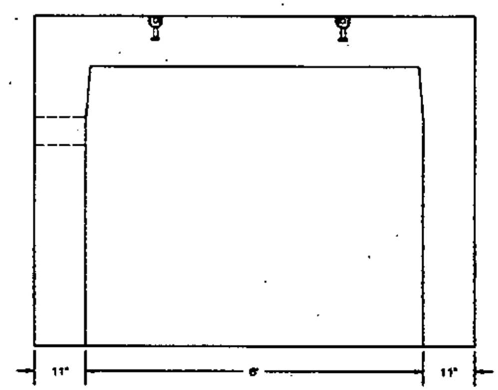

PLAN VIEW




ELEVATION VIEW

## TYPE IV UNITS

| UNIT HEIGHT (in.) | CUBIC STORAGE (C.F.) | WEIGHT TOP (lbs.) |
|---|---|---|
| 60 | 214.8 | 19990 |




SIDE VIEW


STORMTRAP
P.O. BOX 782
MORRIS, IL 60450
1-87-STORMTRAP


ENGINEER INFORMATION: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19 TECHNOLOGY DR
IRVINE, CA
Phone: 619-291-0707
Fax: 619-291-4165


PROJECT INFORMATION:

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SAN DIEGO, CA
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SCALE:

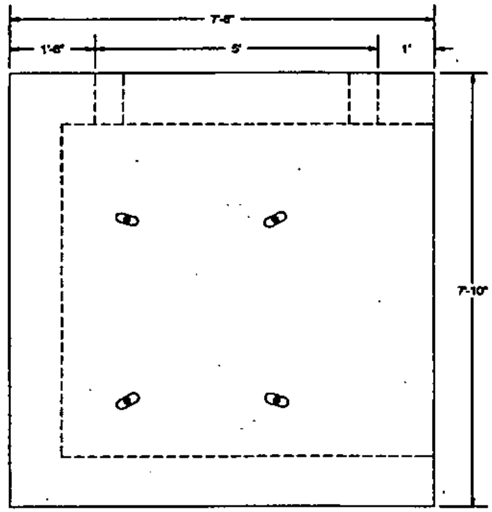
NTS

SHEET TITLE:

STANDARD
5'-0" SINGLETRAP
TYPE IV

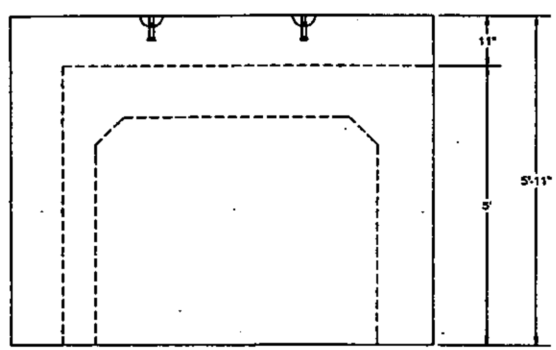
SHEET NUMBER:

07

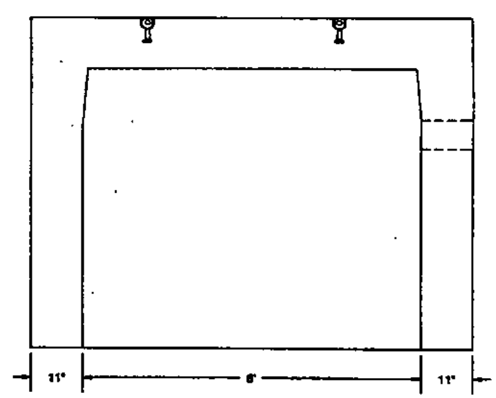



PLAN VIEW

| TYPE V UNITS | | |
|---|---|---|
| UNIT HEIGHT (in.) | CUBIC STORAGE (C.F.) | WEIGHT TOP (lbs.) |
| 60 | 214.8 | 19990 |




ELEVATION VIEW




SIDE VIEW

STORMTRAP
P.O. BOX 782
MORRIS, IL 60450
1-87-STORMTRAP

ENGINEER INFORMATION:

RICK ENGINEERING
19 TECHNOLOGY DR
IRVINE, CA
Phone: 619-291-0707
Fax: 619-291-4165

PROJECT INFORMATION:

COUNTY OF SAN DIEGO
SAN DIEGO, CA
CH-0936-CA-05

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SCALE:

NTS

SHEET TITLE:

STANDARD
5'-0" SINGLETRAP
TYPE V

SHEET NUMBER:

08

## Maintenance Procedures

1. StormTrap should be maintained regularly. Frequency of cleaning will vary due to site conditions and storage capacity. Maintenance is required every 3 to 5 years or when sediment occupies more than one-third of the system's volume. Inspections should be part of Standard Operating Procedure.

2. DO NOT enter StormTrap unless properly trained, equipped and qualified to enter a confined space as identified by local Occupational Safety and Health Regulations.

3. Maintenance is performed using a vacuum truck. A catch basin vacuum truck is not recommended for maintenance. Remove cover from unit from grade and lower hose into chamber. Vacuum trucks are able to remove material from a maximum distance of thirty-two feet below grade; additional charges may apply if installation is deeper.

StormTrap, LLC
2495 West Bungalow Road
Morris, Illinois 60450
Phone (877) 867-6872
Fax (815) 416-1100
Website www.stormtrap.com

September 2004

**Product Guide Specification**

Specifier Notes: This product guide specification is written according to the Construction Specifications Institute (CSI) 3-Part Format, including *MasterFormat, SectionFormat,* and *PageFormat,* contained in the CSI *Manual of Practice.*

The section must be carefully reviewed and edited by the Engineer to meet the requirements of the project and local building code. Coordinate this section with other specification sections and the Drawings. Delete all "Specifier Notes" when editing this section.

Section numbers are from *MasterFormat 1995 Edition,* with numbers from *MasterFormat 2004 Edition* in parentheses. Delete version not required.

## SECTION 02635 (33 49 23)

## STORM WATER DETENTION

Specifier Notes: This section covers "StormTrap®" precast concrete, modular, storm water detention. StormTrap will be custom designed to meet the specific requirements of the project. Flexible design allows for the infiltration of storm water or a semi-contained system.

Consult StormTrap for assistance in editing this section for the specific application.

## PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. Precast concrete, modular, storm water detention.

### 1.2 RELATED SECTIONS

Specifier Notes: Edit the following list of related sections as required for the project. List other sections with work directly related to this section.

A. Section 02300 (31 00 00) - Earthwork.

Specifier Notes: Include Section 03300 (03 30 00) as a related section when specifying SingleTrap® modules.

B. Section 03300 (03 30 00) - Cast-in-Place Concrete.

C. Section 03400 (03 40 00) - Precast Concrete.

## 1.3 REFERENCES

| |
|---|
| Specifier Notes: List standards referenced in this section, complete with designations and titles. This article does not require compliance with standards, but is merely a listing of those used. |

A. ACI 318 - Building Code Requirements for Structural Concrete.

B. ASTM A 615/A 615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

C. ASTM C 857 - Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.

D. ASTM C 858 - Standard Specification for Underground Precast Concrete Utility Structures.

E. ASTM C 891 - Standard Practice for Installation of Underground Precast Concrete Utility Structures.

F. ASTM C 990 - Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.

## 1.4 DESIGN REQUIREMENTS

A. Precast Concrete Modular Storm Water Detention: ASTM C 858.

B. Minimum Structural Design Loading: ASTM C 857.
1. Total Cover:
a. Minimum: 6 inches.

| |
|---|
| Specifier Notes: Consult StormTrap if additional cover is required. |

b. Maximum: 2'-10".
2. Concrete chamber shall be designed for AASHTO HS-20 wheel load and applicable impact.
3. Minimum Soil Pressure:

| |
|---|
| Specifier Notes: Specify minimum soil pressure for SingleTrap® or DoubleTrap® modules. |

a. SingleTrap Modules: 1,500 psf.
b. DoubleTrap Modules: 2,000 psf.
4. Vertical and lateral soil pressures shall be determined using:
a. Groundwater: 3'-0" below grade.

| |
|---|
| Specifier Notes: Provide quantity of water storage required. |

C. Water Storage Required: __________ cubic feet.

## 1.5 SUBMITTALS

A. Comply with Section 01330 (01 33 00) - Submittal Procedures, except shop drawings shall be 11 inches by 17 inches.

B. Product Data: Submit manufacturer's product data and installation instructions.

C. Shop Drawings:
   1. Submit manufacturer's shop drawings, including plans, elevations, sections, and details, indicating layout, dimensions, foundation, cover, and joints.
   2. Indicate size and location of roof openings and inlet and outlet pipe openings.
   3. Indicate sealing of joints.

## 1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery of Accessories: Deliver to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.

B. Storage of Accessories:
   1. Store in accordance with manufacturer's instructions.
   2. Store in clean, dry area, out of direct sunlight.
   3. Store between 40 and 90 degrees F.

C. Handling: Protect materials during handling and installation to prevent damage.

# PART 2 PRODUCTS

## 2.1 MANUFACTURER

A. StormTrap, LLC, 2495 West Bungalow Road, Morris, Illinois 60450. Phone (877) 867-6872. Fax (815) 416-1100. Website www.stormtrap.com.

## 2.2 STORM WATER DETENTION

A. Storm Water Detention Modules: "StormTrap".
   1. Description: Engineered, precast concrete, modular, storm water detention.

| Specifier Notes: Specify SingleTrap® or DoubleTrap® modules. |
|---|

   2. Module Type: [SingleTrap] [DoubleTrap].
   3. Size: As indicated on the Drawings.

| Specifier Notes: Specify the concrete using **one** of the following **two** descriptions. |
|---|

   4. Concrete:
      a. Minimum Compressive Strength: 6,000 psi at 28 days.
      b. Entrained Air Content: 5 to 8 percent.
      c. Maximum Slump: 4 inches.
   5. Concrete: ____________________.

6. Reinforcing Bars: ASTM A 615, Grade 60.
7. Cover for Reinforcing Bars: ACI 318.

## 2.3 ACCESSORIES

A. Joint Tape:
   1. ASTM C 990.
   2. 7/8-inch diameter, preformed mastic joint sealer.
   3. Approved by manufacturer.

B. Joint Wrap:
   1. 12-inch wide sealant with protective release paper.
   2. Approved by manufacturer.

# PART 3 EXECUTION

## 3.1 EXAMINATION

A. Examine area to receive storm water detention modules. Notify Engineer if area is not acceptable. Do not begin installation until unacceptable conditions have been corrected.

B. Verify in field before installation, dimensions and soil conditions, including groundwater and soil bearing capacity.

## 3.2 INSTALLATION

A. Install storm water detention modules in accordance with manufacturer's instructions and ASTM C 891.

B. Install modules plumb, on line, and to proper elevation.

C. Install modules with maximum space of 3/4 inch between adjacent modules.

| Specifier Notes: Include the following **two** paragraphs for SingleTrap® modules. |
|---|

D. Place modules on level, cast-in-place concrete foundation with 1-foot overhang as indicated on the Drawings.

E. Cast-in-place concrete for foundation shall be as specified in Section 03300 (03 30 00) and as follows:
   1. Minimum Compressive Strength: 4,000 psi at 28 days.
   2. Entrained Air Content: 5 to 8 percent.
   3. Maximum Slump: 4 inches.

| Specifier Notes: Include the following paragraph for DoubleTrap® modules. |
|---|

F. Place modules on level, 6-inch pad of 3/4-inch stone that extends 2'-0" past outside of system as indicated on the Drawings.

| Specifier Notes: Include the following paragraph for SingleTrap® modules. |
|---|

G. Joint Tape:
1. Seal perimeter horizontal joint of modules to concrete foundations with joint tape in accordance with ASTM C 891, 8.8 and 8.12.
2. Prepare surfaces and install joint tape in accordance with manufacturer's instructions.

| Specifier Notes: Include the following paragraph for DoubleTrap® modules. |
| --- |

H. Joint Tape:
1. Seal perimeter horizontal joint between modules with joint tape in accordance with ASTM C 891, 8.8 and 8.12.
2. Prepare surfaces and install joint tape in accordance with manufacturer's instructions.

I. Joint Wrap:
1. Seal exterior joints between adjacent modules with joint wrap in accordance with ASTM C 891.
2. Prepare surfaces and install joint wrap in accordance with manufacturer's instructions.

J. Fill:
1. Deposit fill on both sides of modules at same time and to approximate same elevation.
2. Prevent wedging action against structure by stepping or serrating slopes bounding or within area to be backfilled.
3. Do not disrupt or damage joint wrap from joints during backfilling.

K. Excavation and fill shall be as specified in Section 02300 (31 00 00).

L. Do not use storm water detention modules that are damaged, as determined by manufacturer.

**END OF SECTION**

# APPENDIX F

## Drawdown Time Calculation

## DRAWDOWN TIME (with Low Flow Vertical Orifice):

**Enter information in yellow boxes. All other information is self-generated.**

Description of low flow outlet works: 24-inch PVC outlet pipe. Steel Plate bolted to outlet such that a 2-inch (wide) vertical notch extends vertically 24-inches from the flowline of the pipe.

| | inches | feet | Radius | |
|---|---|---|---|---|
| Diameter of **Outlet Pipe**, D (in.): | 24 | 2 | 1 | ft |
| Height of Weir, Hd (ft.): | 24-inch max | 2.000 | | |
| Width of Weir, L (in.): | 2 | | | |

Invert Elevation, Z (ft): 100 reference datum

Step Increments for Drawdown Time (min): 10

*Based on Rating Curve:*

Assumed Clogging Factor (%): 50%

0.6 Orifice  $A_{orifice}$ =  $Q_{orifice}$ = [1-CF%]*CA(2gHo)0.5  EL@$V_{REM}$ = y = 0.0008x + 100

| Water Surface Elevation, E | Volume, V ($ft^3$) | C | Area, A ($ft^2$) | Head, $H_o$ (ft) | Discharge, $Q_{OUT}$ (cfs) | Duration, T (min) | Volume Out, $V_{OUT}$ ($ft^3$) | Volume Remaining, $V_{REM}$ ($ft^3$) | Elevation at $V_{REM}$ | Total Drawdown Time, $T_{TOT}$ (hours) |
|---|---|---|---|---|---|---|---|---|---|---|
| 105.00 | 6523 | 0.6 | 0.33 | 4.00 | 1.60 | 10 | 963 | 5560 | 104.28 | 0.17 |
| 104.28 | 5560 | 0.6 | 0.33 | 3.28 | 1.45 | 10 | 872 | 4688 | 103.61 | 0.33 |
| 103.61 | 4688 | 0.6 | 0.33 | 2.61 | 1.30 | 10 | 778 | 3910 | 103.01 | 0.50 |
| 103.01 | 3910 | 0.6 | 0.33 | 2.01 | 1.14 | 10 | 683 | 3227 | 102.48 | 0.67 |
| 102.48 | 3227 | 0.6 | 0.33 | 1.48 | 0.98 | 10 | 587 | 2640 | 102.03 | 0.83 |
| 102.03 | 2640 | 0.6 | 0.33 | 1.03 | 0.82 | 10 | 489 | 2151 | 101.66 | 1.00 |
| 101.66 | 2151 | 0.6 | 0.28 | 1.02 | 0.67 | 10 | 402 | 1749 | 101.35 | 1.17 |
| 101.35 | 1749 | 0.6 | 0.22 | 0.83 | 0.49 | 10 | 295 | 1454 | 101.12 | 1.33 |
| 101.12 | 1454 | 0.6 | 0.19 | 0.67 | 0.37 | 10 | 221 | 1233 | 100.95 | 1.50 |
| 100.95 | 1233 | 0.6 | 0.16 | 0.56 | 0.28 | 10 | 171 | 1062 | 100.82 | 1.67 |
| 100.82 | 1062 | 0.6 | 0.14 | 0.47 | 0.23 | 10 | 136 | 926 | 100.71 | 1.83 |
| 100.71 | 926 | 0.6 | 0.12 | 0.41 | 0.18 | 10 | 110 | 816 | 100.63 | 2.00 |
| 100.63 | 816 | 0.6 | 0.10 | 0.36 | 0.15 | 10 | 90 | 726 | 100.56 | 2.17 |
| 100.56 | 726 | 0.6 | 0.09 | 0.31 | 0.13 | 10 | 75 | 651 | 100.50 | 2.33 |
| 100.50 | 651 | 0.6 | 0.08 | 0.28 | 0.11 | 10 | 64 | 587 | 100.45 | 2.50 |
| 100.45 | 587 | 0.6 | 0.08 | 0.25 | 0.09 | 10 | 54 | 532 | 100.41 | 2.67 |
| 100.41 | 532 | 0.6 | 0.07 | 0.23 | 0.08 | 10 | 47 | 485 | 100.37 | 2.83 |
| 100.37 | 485 | 0.6 | 0.06 | 0.20 | 0.07 | 10 | 41 | 445 | 100.34 | 3.00 |
| 100.34 | 445 | 0.6 | 0.06 | 0.19 | 0.06 | 10 | 36 | 409 | 100.31 | 3.17 |
| 100.31 | 409 | 0.6 | 0.05 | 0.17 | 0.05 | 10 | 31 | 378 | 100.29 | 3.33 |
| 100.29 | 378 | 0.6 | 0.05 | 0.16 | 0.05 | 10 | 28 | 350 | 100.27 | 3.50 |
| 100.27 | 350 | 0.6 | 0.04 | 0.15 | 0.04 | 10 | 25 | 325 | 100.25 | 3.67 |
| 100.25 | 325 | 0.6 | 0.04 | 0.13 | 0.04 | 10 | 22 | 303 | 100.23 | 3.83 |
| 100.23 | 303 | 0.6 | 0.04 | 0.13 | 0.03 | 10 | 20 | 283 | 100.22 | 4.00 |
| 100.22 | 283 | 0.6 | 0.04 | 0.12 | 0.03 | 10 | 18 | 265 | 100.20 | 4.17 |
| 100.20 | 265 | 0.6 | 0.03 | 0.11 | 0.03 | 10 | 16 | 249 | 100.19 | 4.33 |
| 100.19 | 249 | 0.6 | 0.03 | 0.10 | 0.02 | 10 | 15 | 234 | 100.18 | 4.50 |
| 100.18 | 234 | 0.6 | 0.03 | 0.10 | 0.02 | 10 | 13 | 221 | 100.17 | 4.67 |
| 100.17 | 221 | 0.6 | 0.03 | 0.09 | 0.02 | 10 | 12 | 209 | 100.16 | 4.83 |
| 100.16 | 209 | 0.6 | 0.03 | 0.09 | 0.02 | 10 | 11 | 197 | 100.15 | 5.00 |
| 100.15 | 197 | 0.6 | 0.03 | 0.08 | 0.02 | 10 | 10 | 187 | 100.14 | 5.17 |
| 100.14 | 187 | 0.6 | 0.02 | 0.08 | 0.02 | 10 | 10 | 177 | 100.14 | 5.33 |
| 100.14 | 177 | 0.6 | 0.02 | 0.07 | 0.01 | 10 | 9 | 169 | 100.13 | 5.50 |
| 100.13 | 169 | 0.6 | 0.02 | 0.07 | 0.01 | 10 | 8 | 160 | 100.12 | 5.67 |
| 100.12 | 160 | 0.6 | 0.02 | 0.06 | 0.01 | 10 | 8 | 153 | 100.12 | 5.83 |
| 100.12 | 153 | 0.6 | 0.02 | 0.06 | 0.01 | 10 | 7 | 146 | 100.11 | 6.00 |
| 100.11 | 146 | 0.6 | 0.02 | 0.06 | 0.01 | 10 | 7 | 139 | 100.11 | 6.17 |
| 100.11 | 139 | 0.6 | 0.02 | 0.06 | 0.01 | 10 | 6 | 133 | 100.10 | 6.33 |
| 100.10 | 133 | 0.6 | 0.02 | 0.05 | 0.01 | 10 | 6 | 127 | 100.10 | 6.50 |
| 100.10 | 127 | 0.6 | 0.02 | 0.05 | 0.01 | 10 | 5 | 122 | 100.09 | 6.67 |
| 100.09 | 122 | 0.6 | 0.02 | 0.05 | 0.01 | 10 | 5 | 117 | 100.09 | 6.83 |
| 100.09 | 117 | 0.6 | 0.02 | 0.05 | 0.01 | 10 | 5 | 112 | 100.09 | 7.00 |
| 100.09 | 112 | 0.6 | 0.01 | 0.05 | 0.01 | 10 | 4 | 108 | 100.08 | 7.17 |

| Water Surface Elevation, E | Volume, V ($ft^3$) | C | Area, A ($ft^2$) | Head, $H_e$ (ft) | Discharge, $Q_{OUT}$ (cfs) | Duration, T (min) | Volume Out, $V_{OUT}$ ($ft^3$) | Volume Remaining, $V_{REM}$ ($ft^3$) | Elevation at $V_{REM}$ | Total Drawdown Time, $T_{TOT}$ (hours) |
|---|---|---|---|---|---|---|---|---|---|---|
| 100.08 | 108 | 0.6 | 0.01 | 0.04 | 0.01 | 10 | 4 | 104 | 100.08 | 7.33 |
| 100.08 | 104 | 0.6 | 0.01 | 0.04 | 0.01 | 10 | 4 | 100 | 100.08 | 7.50 |
| 100.08 | 100 | 0.6 | 0.01 | 0.04 | 0.01 | 10 | 4 | 96 | 100.07 | 7.67 |
| 100.07 | 96 | 0.6 | 0.01 | 0.04 | 0.01 | 10 | 3 | 93 | 100.07 | 7.83 |
| 100.07 | 93 | 0.6 | 0.01 | 0.04 | 0.01 | 10 | 3 | 89 | 100.07 | 8.00 |
| 100.07 | 89 | 0.6 | 0.01 | 0.04 | 0.01 | 10 | 3 | 86 | 100.07 | 8.17 |
| 100.07 | 86 | 0.6 | 0.01 | 0.03 | 0.00 | 10 | 3 | 83 | 100.06 | 8.33 |
| 100.06 | 83 | 0.6 | 0.01 | 0.03 | 0.00 | 10 | 3 | 80 | 100.06 | 8.50 |
| 100.06 | 80 | 0.6 | 0.01 | 0.03 | 0.00 | 10 | 3 | 78 | 100.06 | 8.67 |
| 100.06 | 78 | 0.6 | 0.01 | 0.03 | 0.00 | 10 | 3 | 75 | 100.06 | 8.83 |
| 100.06 | 75 | 0.6 | 0.01 | 0.03 | 0.00 | 10 | 2 | 73 | 100.06 | 9.00 |
| 100.06 | 73 | 0.6 | 0.01 | 0.03 | 0.00 | 10 | 2 | 71 | 100.05 | 9.17 |
| 100.05 | 71 | 0.6 | 0.01 | 0.03 | 0.00 | 10 | 2 | 68 | 100.05 | 9.33 |
| 100.05 | 68 | 0.6 | 0.01 | 0.03 | 0.00 | 10 | 2 | 66 | 100.05 | 9.50 |
| 100.05 | 66 | 0.6 | 0.01 | 0.03 | 0.00 | 10 | 2 | 64 | 100.05 | 9.67 |
| 100.05 | 64 | 0.6 | 0.01 | 0.03 | 0.00 | 10 | 2 | 62 | 100.05 | 9.83 |
| 100.05 | 62 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 2 | 61 | 100.05 | 10.00 |
| 100.05 | 61 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 2 | 59 | 100.05 | 10.17 |
| 100.05 | 59 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 2 | 57 | 100.04 | 10.33 |
| 100.04 | 57 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 2 | 56 | 100.04 | 10.50 |
| 100.04 | 56 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 2 | 54 | 100.04 | 10.67 |
| 100.04 | 54 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 1 | 53 | 100.04 | 10.83 |
| 100.04 | 53 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 1 | 51 | 100.04 | 11.00 |
| 100.04 | 51 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 1 | 50 | 100.04 | 11.17 |
| 100.04 | 50 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 1 | 48 | 100.04 | 11.33 |
| 100.04 | 48 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 1 | 47 | 100.04 | 11.50 |
| 100.04 | 47 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 1 | 46 | 100.04 | 11.67 |
| 100.04 | 46 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 1 | 45 | 100.03 | 11.83 |
| 100.03 | 45 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 1 | 44 | 100.03 | 12.00 |
| 100.03 | 44 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 1 | 43 | 100.03 | 12.17 |
| 100.03 | 43 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 1 | 42 | 100.03 | 12.33 |
| 100.03 | 42 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 1 | 41 | 100.03 | 12.50 |
| 100.03 | 41 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 1 | 40 | 100.03 | 12.67 |
| 100.03 | 40 | 0.6 | 0.01 | 0.02 | 0.00 | 10 | 1 | 39 | 100.03 | 12.83 |
| 100.03 | 39 | 0.6 | 0.00 | 0.02 | 0.00 | 10 | 1 | 38 | 100.03 | 13.00 |
| 100.03 | 38 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 37 | 100.03 | 13.17 |
| 100.03 | 37 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 36 | 100.03 | 13.33 |
| 100.03 | 36 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 35 | 100.03 | 13.50 |
| 100.03 | 35 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 35 | 100.03 | 13.67 |
| 100.03 | 35 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 34 | 100.03 | 13.83 |
| 100.03 | 34 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 33 | 100.03 | 14.00 |
| 100.03 | 33 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 32 | 100.03 | 14.17 |
| 100.03 | 32 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 32 | 100.02 | 14.33 |
| 100.02 | 32 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 31 | 100.02 | 14.50 |
| 100.02 | 31 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 31 | 100.02 | 14.67 |
| 100.02 | 31 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 30 | 100.02 | 14.83 |
| 100.02 | 30 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 29 | 100.02 | 15.00 |

| Water Surface Elevation, E | Volume, V ($ft^3$) | C | Area, A ($ft^2$) | Head, $H_e$ (ft) | Discharge, $Q_{OUT}$ (cfs) | Duration, T (min) | Volume Out, $V_{OUT}$ ($ft^3$) | Volume Remaining, $V_{REM}$ ($ft^3$) | Elevation at $V_{REM}$ | Total Drawdown Time, $T_{TOT}$ (hours) |
|---|---|---|---|---|---|---|---|---|---|---|
| 100.02 | 29 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 29 | 100.02 | 15.17 |
| 100.02 | 29 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 28 | 100.02 | 15.33 |
| 100.02 | 28 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 28 | 100.02 | 15.50 |
| 100.02 | 28 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 27 | 100.02 | 15.67 |
| 100.02 | 27 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 27 | 100.02 | 15.83 |
| 100.02 | 27 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 1 | 26 | 100.02 | 16.00 |
| 100.02 | 26 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 26 | 100.02 | 16.17 |
| 100.02 | 26 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 25 | 100.02 | 16.33 |
| 100.02 | 25 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 25 | 100.02 | 16.50 |
| 100.02 | 25 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 24 | 100.02 | 16.67 |
| 100.02 | 24 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 24 | 100.02 | 16.83 |
| 100.02 | 24 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 23 | 100.02 | 17.00 |
| 100.02 | 23 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 23 | 100.02 | 17.17 |
| 100.02 | 23 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 22 | 100.02 | 17.33 |
| 100.02 | 22 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 22 | 100.02 | 17.50 |
| 100.02 | 22 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 22 | 100.02 | 17.67 |
| 100.02 | 22 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 21 | 100.02 | 17.83 |
| 100.02 | 21 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 21 | 100.02 | 18.00 |
| 100.02 | 21 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 21 | 100.02 | 18.17 |
| 100.02 | 21 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 20 | 100.02 | 18.33 |
| 100.02 | 20 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 20 | 100.02 | 18.50 |
| 100.02 | 20 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 20 | 100.02 | 18.67 |
| 100.02 | 20 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 19 | 100.01 | 18.83 |
| 100.01 | 19 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 19 | 100.01 | 19.00 |
| 100.01 | 19 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 19 | 100.01 | 19.17 |
| 100.01 | 19 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 18 | 100.01 | 19.33 |
| 100.01 | 18 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 18 | 100.01 | 19.50 |
| 100.01 | 18 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 18 | 100.01 | 19.67 |
| 100.01 | 18 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 18 | 100.01 | 19.83 |
| 100.01 | 18 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 17 | 100.01 | 20.00 |
| 100.01 | 17 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 17 | 100.01 | 20.17 |
| 100.01 | 17 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 17 | 100.01 | 20.33 |
| 100.01 | 17 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 17 | 100.01 | 20.50 |
| 100.01 | 17 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 16 | 100.01 | 20.67 |
| 100.01 | 16 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 16 | 100.01 | 20.83 |
| 100.01 | 16 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 16 | 100.01 | 21.00 |
| 100.01 | 16 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 16 | 100.01 | 21.17 |
| 100.01 | 16 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 15 | 100.01 | 21.33 |
| 100.01 | 15 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 15 | 100.01 | 21.50 |
| 100.01 | 15 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 15 | 100.01 | 21.67 |
| 100.01 | 15 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 15 | 100.01 | 21.83 |
| 100.01 | 15 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 14 | 100.01 | 22.00 |
| 100.01 | 14 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 14 | 100.01 | 22.17 |
| 100.01 | 14 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 14 | 100.01 | 22.33 |
| 100.01 | 14 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 14 | 100.01 | 22.50 |
| 100.01 | 14 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 14 | 100.01 | 22.67 |
| 100.01 | 14 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 14 | 100.01 | 22.83 |
| 100.01 | 14 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 13 | 100.01 | 23.00 |
| 100.01 | 13 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 13 | 100.01 | 23.17 |
| 100.01 | 13 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 13 | 100.01 | 23.33 |
| 100.01 | 13 | 0.6 | 0.00 | 0.01 | 0.00 | 10 | 0 | 13 | 100.01 | 23.50 |
| 100.01 | 13 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 13 | 100.01 | 23.67 |
| 100.01 | 13 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 12 | 100.01 | 23.83 |
| 100.01 | 12 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 12 | 100.01 | 24.00 |
| 100.01 | 12 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 12 | 100.01 | 24.17 |
| 100.01 | 12 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 12 | 100.01 | 24.33 |
| 100.01 | 12 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 12 | 100.01 | 24.50 |
| 100.01 | 12 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 12 | 100.01 | 24.67 |
| 100.01 | 12 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 12 | 100.01 | 24.83 |
| 100.01 | 12 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 11 | 100.01 | 25.00 |
| 100.01 | 11 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 11 | 100.01 | 25.17 |

| Water Surface Elevation, E | Volume, V ($ft^3$) | C | Area, A ($ft^2$) | Head, $H_e$ (ft) | Discharge, $Q_{OUT}$ (cfs) | Duration, T (min) | Volume Out, $V_{OUT}$ ($ft^3$) | Volume Remaining, $V_{REM}$ ($ft^3$) | Elevation at $V_{REM}$ | Total Drawdown Time, $T_{TOT}$ (hours) |
|---|---|---|---|---|---|---|---|---|---|---|
| 100.01 | 11 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 11 | 100.01 | 25.33 |
| 100.01 | 11 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 11 | 100.01 | 25.50 |
| 100.01 | 11 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 11 | 100.01 | 25.67 |
| 100.01 | 11 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 11 | 100.01 | 25.83 |
| 100.01 | 11 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 11 | 100.01 | 26.00 |
| 100.01 | 11 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 10 | 100.01 | 26.17 |
| 100.01 | 10 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 10 | 100.01 | 26.33 |
| 100.01 | 10 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 10 | 100.01 | 26.50 |
| 100.01 | 10 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 10 | 100.01 | 26.67 |
| 100.01 | 10 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 10 | 100.01 | 26.83 |
| 100.01 | 10 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 10 | 100.01 | 27.00 |
| 100.01 | 10 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 10 | 100.01 | 27.17 |
| 100.01 | 10 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 10 | 100.01 | 27.33 |
| 100.01 | 10 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 10 | 100.01 | 27.50 |
| 100.01 | 10 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 9 | 100.01 | 27.67 |
| 100.01 | 9 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 9 | 100.01 | 27.83 |
| 100.01 | 9 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 9 | 100.01 | 28.00 |
| 100.01 | 9 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 9 | 100.01 | 28.17 |
| 100.01 | 9 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 9 | 100.01 | 28.33 |
| 100.01 | 9 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 9 | 100.01 | 28.50 |
| 100.01 | 9 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 9 | 100.01 | 28.67 |
| 100.01 | 9 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 9 | 100.01 | 28.83 |
| 100.01 | 9 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 9 | 100.01 | 29.00 |
| 100.01 | 9 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 9 | 100.01 | 29.17 |
| 100.01 | 9 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 8 | 100.01 | 29.33 |
| 100.01 | 8 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 8 | 100.01 | 29.50 |
| 100.01 | 8 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 8 | 100.01 | 29.67 |
| 100.01 | 8 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 8 | 100.01 | 29.83 |
| 100.01 | 8 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 8 | 100.01 | 30.00 |
| 100.01 | 8 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 8 | 100.01 | 30.17 |
| 100.01 | 8 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 8 | 100.01 | 30.33 |
| 100.01 | 8 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 8 | 100.01 | 30.50 |
| 100.01 | 8 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 8 | 100.01 | 30.67 |
| 100.01 | 8 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 8 | 100.01 | 30.83 |
| 100.01 | 8 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 8 | 100.01 | 31.00 |
| 100.01 | 8 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 8 | 100.01 | 31.17 |
| 100.01 | 8 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 7 | 100.01 | 31.33 |
| 100.01 | 7 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 7 | 100.01 | 31.50 |
| 100.01 | 7 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 7 | 100.01 | 31.67 |
| 100.01 | 7 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 7 | 100.01 | 31.83 |
| 100.01 | 7 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 7 | 100.01 | 32.00 |
| 100.01 | 7 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 7 | 100.01 | 32.17 |
| 100.01 | 7 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 7 | 100.01 | 32.33 |
| 100.01 | 7 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 7 | 100.01 | 32.50 |
| 100.01 | 7 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 7 | 100.01 | 32.67 |
| 100.01 | 7 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 7 | 100.01 | 32.83 |
| 100.01 | 7 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 7 | 100.01 | 33.00 |
| 100.01 | 7 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 7 | 100.01 | 33.17 |
| 100.01 | 7 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 7 | 100.01 | 33.33 |
| 100.01 | 7 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 7 | 100.01 | 33.50 |
| 100.01 | 7 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 7 | 100.01 | 33.67 |
| 100.01 | 7 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 6 | 100.00 | 33.83 |
| 100.00 | 6 | 0.6 | 0.00 | 0.00 | 0.00 | 10 | 0 | 6 | 100.00 | 34.00 |

# APPENDIX G

## Back-up Information for
## Quantities and Cost Estimate Calculations

RICK ENGINEERING COMPANY

*Underground Detention Basin*
*at McClellan-Palomar Airport*
*(Schedule B)*

| No. | Item Description | Unit | Quantity | Unit Price | Item Price |
|---|---|---|---|---|---|
| 1 | Mobilization | LS | 1 | $25,000.00 | $25,000.00 |
| 2 | Trench, Safety & Shoring | LS | 1 | $10,000.00 | $10,000.00 |
| 3 | Temporary Gravel Bags | EA | 150 | $10.00 | $1,500.00 |
| 4 | Temporary Concrete Washout | LS | 1 | $2,000.00 | $2,000.00 |
| 5 | Clearing and Grubbing | LS | 1 | $5,000.00 | $5,000.00 |
| 6 | Dewatering | LS | 1 | $2,500.00 | $2,500.00 |
| 7 | Minor Concrete Structure (Type A-6 Cleanout) | EA | 2 | $20,000.00 | $40,000.00 |
| 8 | Minor Concrete Structure (Modified Type A-6 Cleanout Diversion Box) | EA | 1 | $30,000.00 | $30,000.00 |
| 9 | Minor Concrete Structure (Type A-4 Cleanout) | EA | 2 | $5,000.00 | $10,000.00 |
| 10 | Hydrodynamic Separation | LS | 1 | $151,000.00 | $151,000.00 |
| 11 | Stormwater Detention System | LS | 1 | $270,000.00 | $270,000.00 |
| 12 | 24" Reinforced Concrete Pipe | LS | 28 | $150.00 | $4,200.00 |
| 13 | 36" Reinforced Concrete Pipe | LF | 188 | $250.00 | $47,000.00 |
| 14 | 12" PVC | LF | 20 | $75.00 | $1,500.00 |
| 15 | Field Orders | LS | 1 | $30,000.00 | $30,000.00 |
| | | | | ***Subtotal:*** | $629,700.00 |
| | | | | ***15% Contingency:*** | $94,455.00 |
| | | | | ***Total:*** | $724,155.00 |

**STORMTRAP®**
*PRECAST CONCRETE MODULAR STORM WATER DETENTION*

P.O. BOX 782 - MORRIS IL • 87-STORMTRAP • WWW.STORMTRAP.COM

July 8, 2005

Brendan Hastie
Rick Engineering
19 Technology Dr
Irvine, CA 92618

RE: County of San Diego - San Diego, CA
PROJECT: CH-0938-CA-05

Dear Brendan:

StormTrap, LLC is pleased to offer the following budget estimate for the installation of the StormTrap System for the above stated project. Please note that the estimate assumes that all spoil will be left on site and is exclusive of any applicable taxes. ***Assumptions used for this project are as follows (see page 2 of the design for complete design critera): Cover: 6" (Max of 20'-0"); Groundwater: below system; Loading ASTM C857 HS-20.***

**5'-0" SINGLETRAP**
Total Water Storage Provided: 0.15 Acre-Feet or 6,523 C.F.

| | | | | | | |
|---|---|---|---|---|---|---|
| STORMTRAP MATERIAL COST INCLUDING LINER | | | | | | |
| 28 | StormTrap Units (see attached layout) | | | | | |
| SUB TOTAL FOR MATERIAL AND FREIGHT: | | | | | | **$168,114.00** |
| EXCAVATION | | | | | | |
| 1,324 | C.Y. | @ | $10.00 | PER | C.Y. | $13,240.00 |
| INSTALL STORMTRAP UNITS | | | | | | |
| 56 | PIECES | @ | $300.00 | PER | PIECE | $16,800.00 |
| STONE | | | | | | |
| 32 | C.Y. | @ | $30.00 | PER | C.Y. | $960.00 |
| BACKFILL | | | | | | |
| 589 | C.Y. | @ | $30.00 | PER | C.Y. | $17,670.00 |
| SUB-TOTAL FOR INSTALLATION: | | | | | | **$48,670.00** |
| TOTAL BUDGET ESTIMATE FOR MATERIAL AND INSTALLATION | | | | | | **$216,784.00** |

Please feel free to call me if you have any questions.

Sincerely,

* LUMP SUM ASSUMED FOR ENGINEERS OPINION OF PROBABLE COSTS ≈ $270,000

Cole Herron

RICK™
ENGINEERING COMPANY
5620 Friars Road
San Diego, California 92110-2596
Tel: (619) 291-0707
Fax: (619) 291-4165

Date
Job No.
Page
Done By
Checked By

VORTECHNICS : COSTS

Per emails from Vortechnics on June 28, 2005...

Capital Cost ≈ \$66,000 + \$3,500 for deep cover

(Does not include bringing risers to FG)

Installation ≈ 25% - 30% of Capital Cost

∴ ≈ \$91,000

w/ Four (4) deep risers, excavation & backfill, foundation materials, and select backfill material ...

* ≈ Lump Sum = \$ 151,000

## APPENDIX H

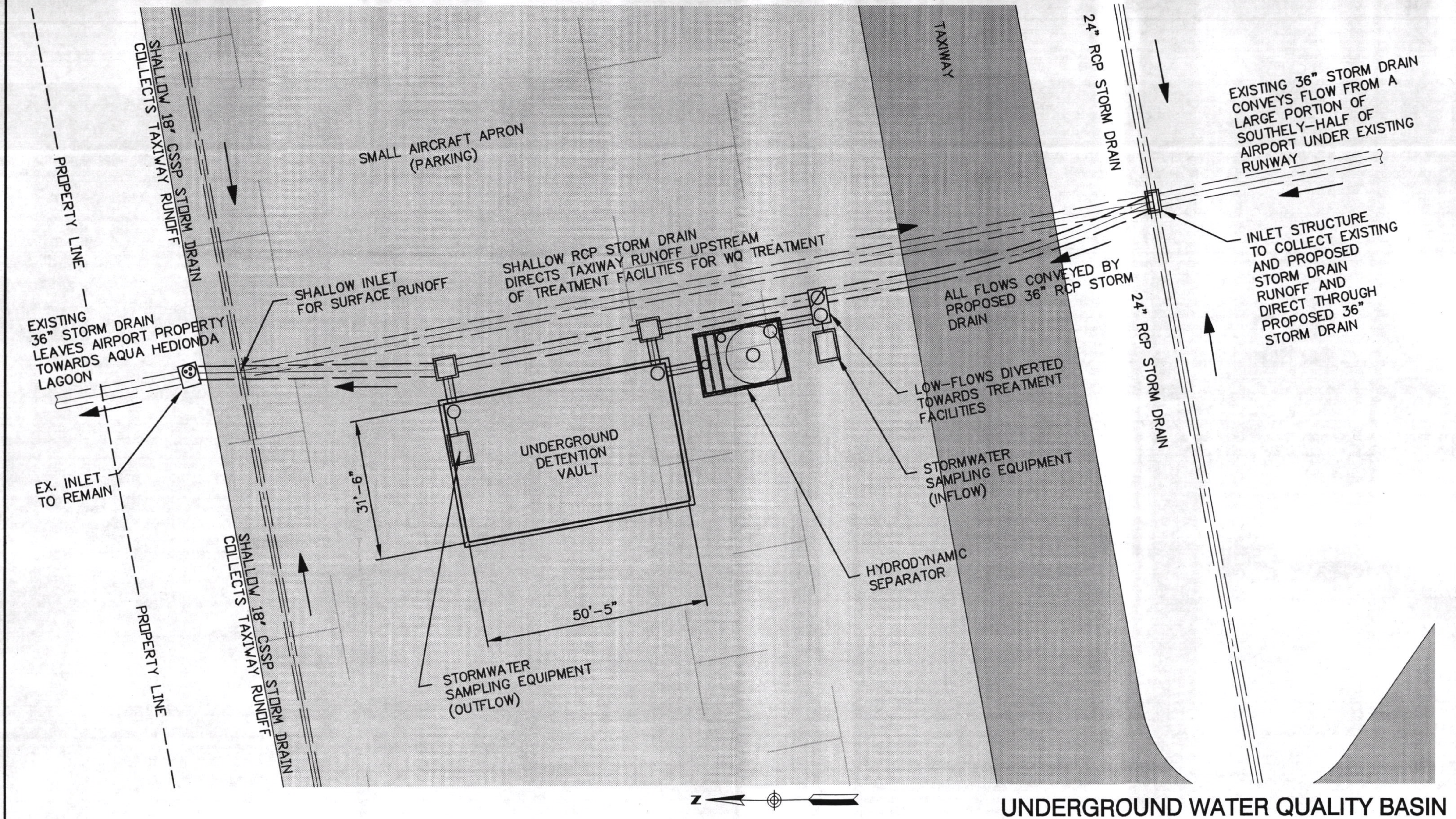
## Basin Layout

## for

## Underground Water Quality Basin

## at

## McClellan-Palomar Airport




# UNDERGROUND WATER QUALITY BASIN @ McCLELLAN-PALOMAR AIRPORT

J-14804-E

DATE: 09-08-06

GRAPHIC SCALE 1"= 20'

20 10 0 20 40 60


RICK ENGINEERING COMPANY

5620 FRIARS ROAD
SAN DIEGO, CA 92110
619.291.0707
(FAX)619.291.4165

rickengineering.com

San Diego | Riverside | Sacramento | Orange | Phoenix | Tucson


W:\14804\14804-E_Palomar_Airport\14804Eexb_drn02_schematic.dgn

# MAP POCKET 1

## Watershed Tributary
## To
## Underground Water Quality Basin
## For
## McClellan-Palomar Airport

**(For Reference Only)**


LEGEND

| | |
|---|---|
| | WATERSHED LIMIT |
| | STORM DRAINS AS OF 4/28/05, PER SITE VISIT |
| 1.9 AC. | DRAINAGE AREA |
| 101 | NODE NUMBER USED FOR MODIFIED RATIONAL METHOD |

N

200 100 0 200 400 600

GRAPHIC SCALE 1"= 200'

# WATERSHED TRIBUTARY TO UNDERGROUND WATER QUALITY BASIN FOR McCLELLAN-PALOMAR AIRPORT

DATE: May 24, 2005
REVISED: August 4, 2005
REVISED: October 10, 2006

J-14804E

RICK ENGINEERING COMPANY
5620 FRIARS ROAD
SAN DIEGO, CA 92110
619.291.0707
(FAX)619.291.4165
rickengineering.com
San Diego Riverside Sacramento Orange Phoenix Tucson

NOT FOR CONSTRUCTION

## MAP POCKET 2

## Copy of Plan Sheets 2 and 4

## for the

## Underground Detention Basin at McClellan-Palomar Airport

**(For Reference Only)**

## ABBREVIATIONS

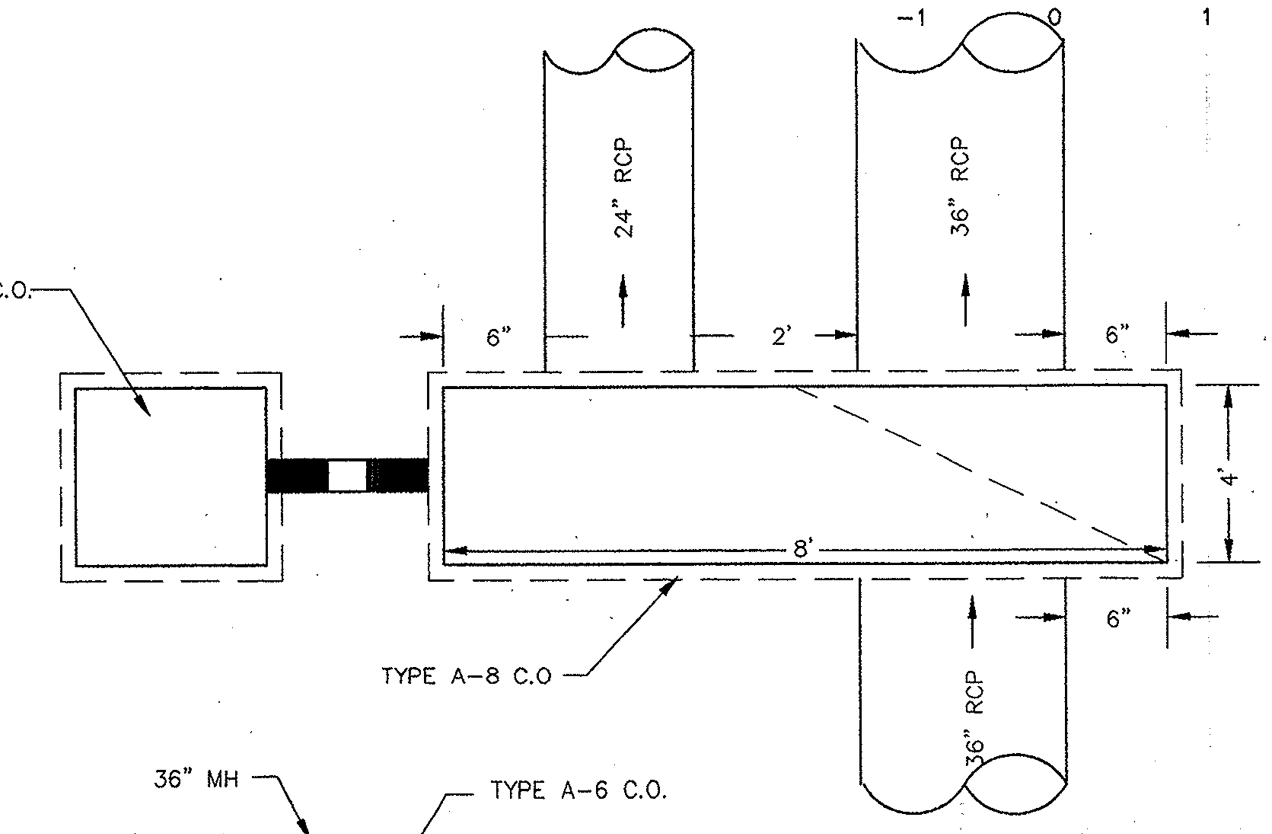
| ABBREVIATION | DESCRIPTION |
|---|---|
| & | AND |
| AB | AGGREGATE BASE |
| AC | ASPHALT CONCRETE |
| ACP | ASBESTOS CEMENT PIPE |
| BC | BEGINNING OF CURVE |
| BVC | BEGINNING OF VERTICAL CURVE |
| C&G | CURB AND GUTTER |
| CFS | CUBIC FEET PER SECOND |
| CI | CAST IRON PIPE |
| CIP | CAST-IN-PLACE |
| C L | CENTERLINE |
| CL | CLASS |
| CO | CLEANOUT |
| CONC | CONCRETE |
| CONST | CONSTRUCT |
| CONST'N | CONSTRUCTION |
| CSP | CORRUGATED STEEL PIPE |
| CSPA | CORRUGATED STEEL PIPE ARCH |
| CTSP | CALTRANS STANDARD PLANS |
| DE | DEAD END |
| Δ | DELTA |
| DRAIN | DRAINAGE |
| DWY | DRIVEWAY |
| EC | END OF CURVE |
| ELEV | ELEVATION |
| EP | EDGE OF PAVEMENT |
| EVC | END OF VERTICAL CURVE |
| EXIST | EXISTING |
| FG | FINISH GRADE |
| FH | FIRE HYDRANT |
| FL | FLOW LINE |
| HH | HANDHOLE |
| HWY | HIGHWAY |
| IE | INVERT ELEVATION |
| L | ARC LENGTH |
| LF | LINEAR FOOT |
| LT | LEFT |
| MH | MANHOLE |
| MIN | MINIMUM |
| NAD | NORTH AMERICAN DATUM |
| OG | ORIGINAL GROUND |
| OHD | OVERHEAD |
| PCC | PORTLAND CEMENT CONCRETE |
| PCR | POINT OF CURB/CURVE RETURN |
| PED | PEDESTRIAN |
| PI | POINT OF INTERSECTION/ANGLE POINT |
| PL | PLACE |
| P | PROPERTY LINE |
| PROF | PROFILE |
| PVI | POINT OF VERTICAL INTERSECTION |
| PVMT | PAVEMENT |
| Q | RATE OF FLOW |
| R | RADIUS |
| RCB | REINFORCED CONCRETE BOX |
| RCP | REINFORCED CONCRETE PIPE |
| RD | ROAD |
| RS | ROAD SURVEY |
| RSD | REGIONAL STANDARD DRAWING |
| RT | RIGHT |
| R/W | RIGHT-OF-WAY |
| SD | STORM DRAIN |
| SDCDS | SAN DIEGO COUNTY DESIGN STANDARD |
| S/W | SIDEWALK |
| S | SLOPE |
| ST | STREET |
| STA | STATION |
| SWR | SANITARY SEWER |
| T | TANGENT LENGTH |
| TC | TOP OF CURB |
| TELE | TELEPHONE |
| TW | TOP OF WALL |
| USC&GS | UNITED STATES COASTAL & GEODETIC SURVEY |
| VC | VERTICAL CURVE LENGTH |
| VCP | VITRIFIED CLAY PIPE |
| WTR | WATER |

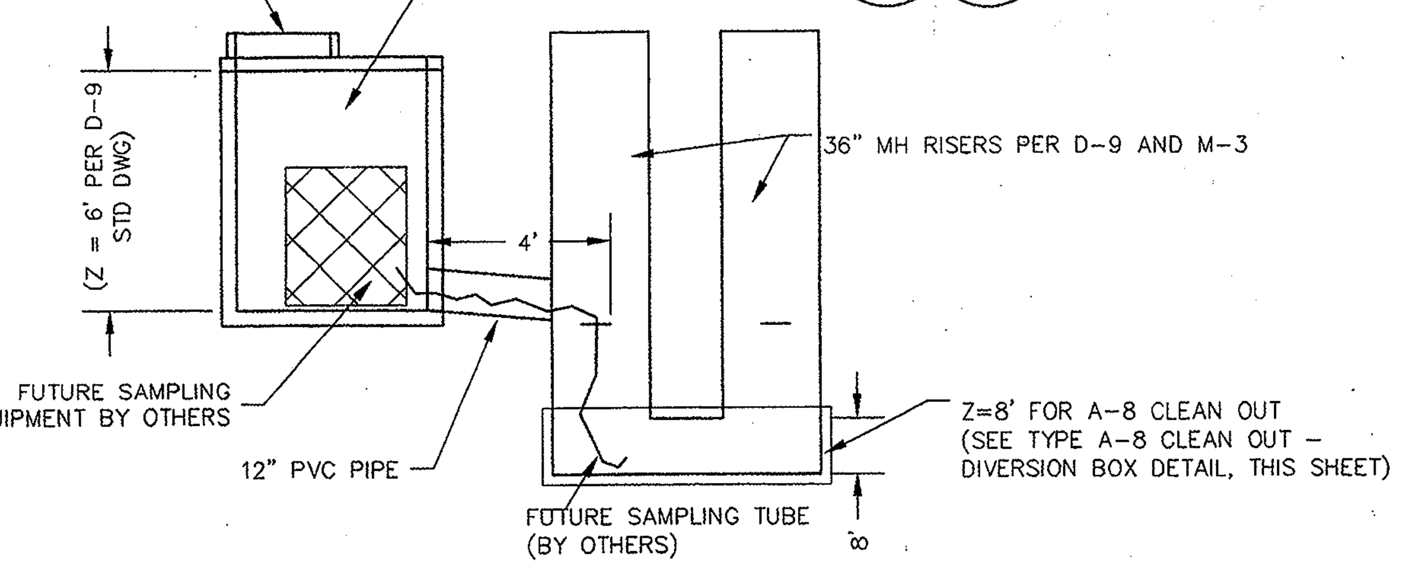
## HORIZONTAL CONTROL & BENCHMARKS

FOR HORIZONTAL CONTROL AND BENCHMARK INFORMATION, REFER TO SHEET 4 OF 63 ON THE McCLELLAN-PALOMAR AIRPORT RUNWAY SAFETY AREA – PHASE 1 PLANS.'

FOR REDUCED PLANS ORIGINAL SCALE IS IN INCHES

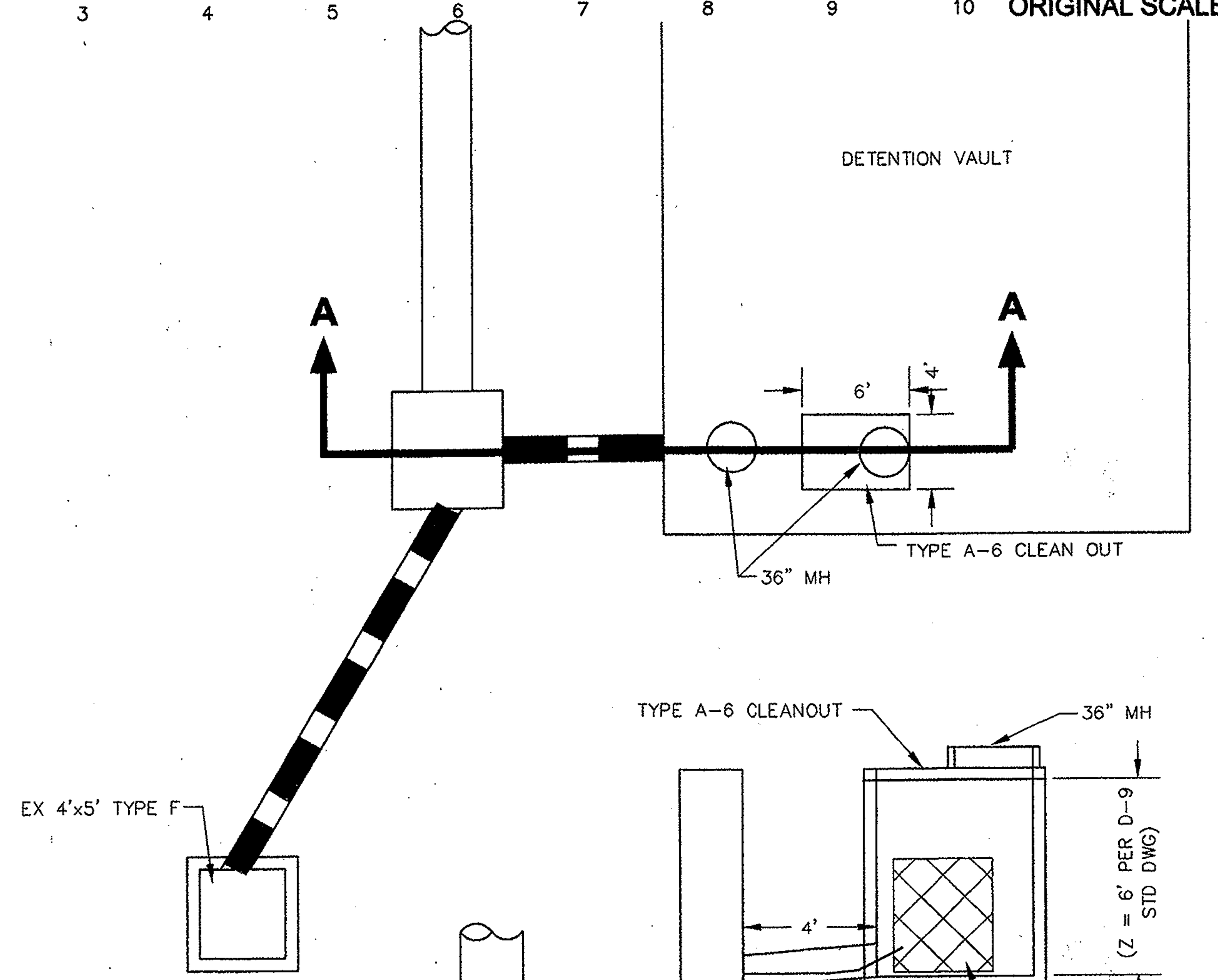
-1 0 1 2 3 4 5 6 7 8 9 10

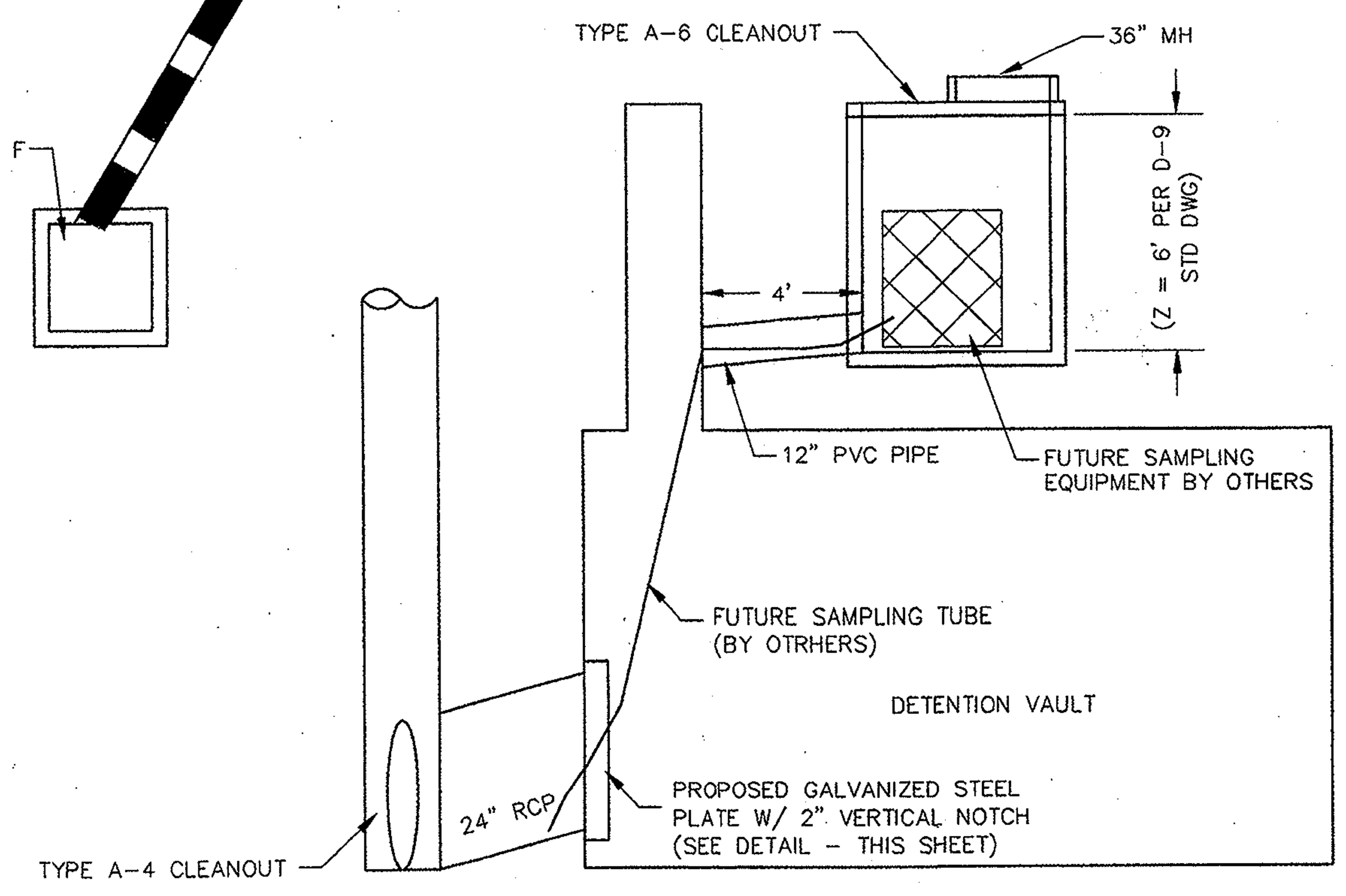



## STORMWATER SAMPLING INFLOW LOCATION - TYPE A6 CLEAN OUT

(NO SCALE)




## SECTION A-A

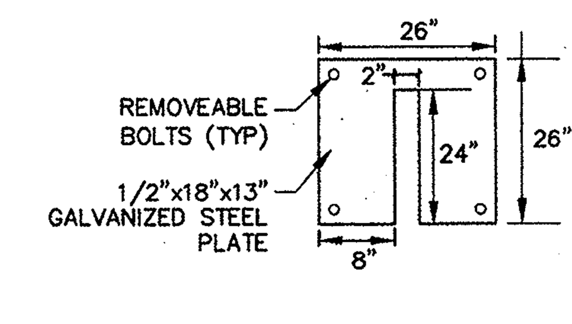
## STORMWATER SAMPLING OUTFLOW LOCATION - TYPE A6 CLEAN OUT

(NO SCALE)

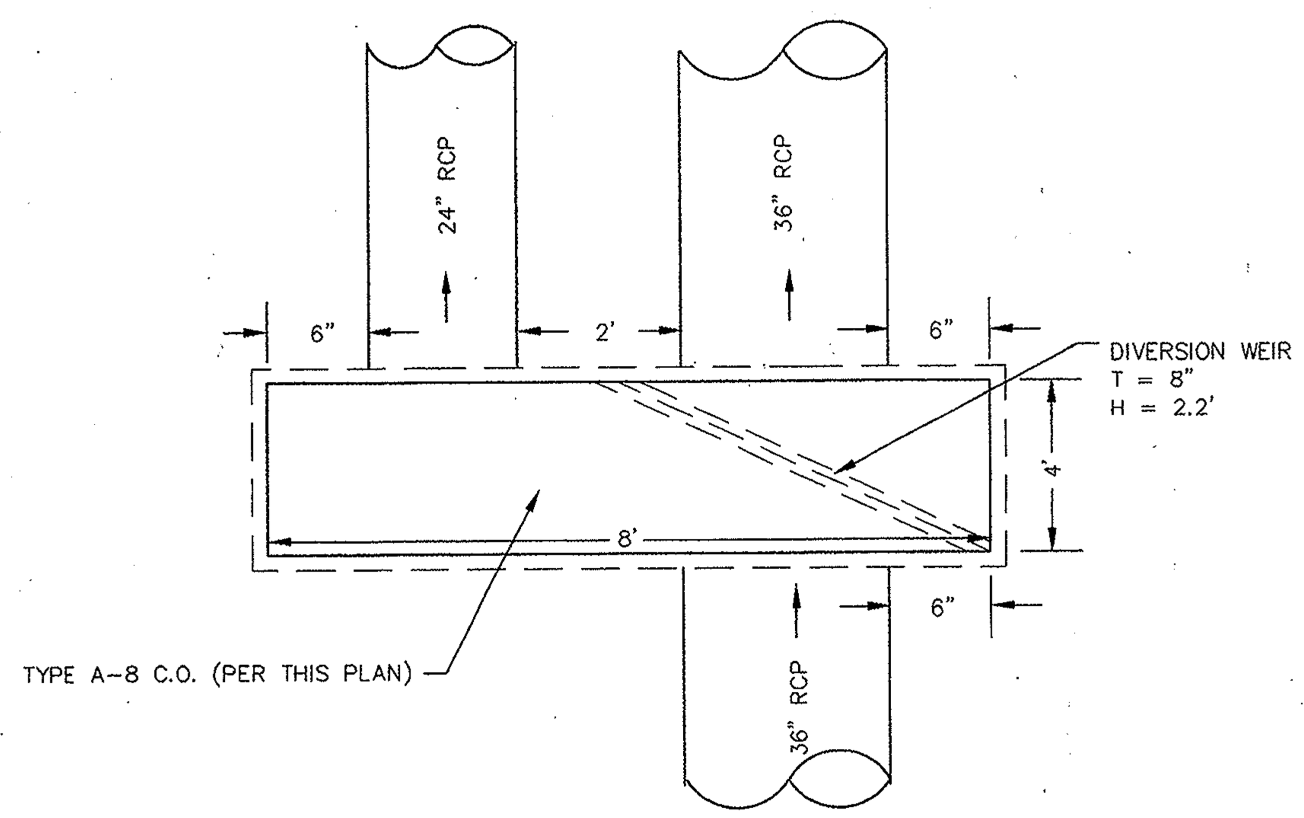

| PLANS | BY | DATE |
|---|---|---|
| DESIGNED | BRENDAN HASTIE | |
| CHECKED | CARL HEWINGS | |
| DELINEATED | | |

RICK ENGINEERING
5620 FRIARS RD.
SAN DIEGO, CA. 92110
619-291-0707
REGISTERED CIVIL ENGINEER 4-17-06 DATE

REGISTERED PROFESSIONAL ENGINEER John D. Goddard No. 33037 Exp. 6/30/06 CIVIL STATE OF CALIFORNIA

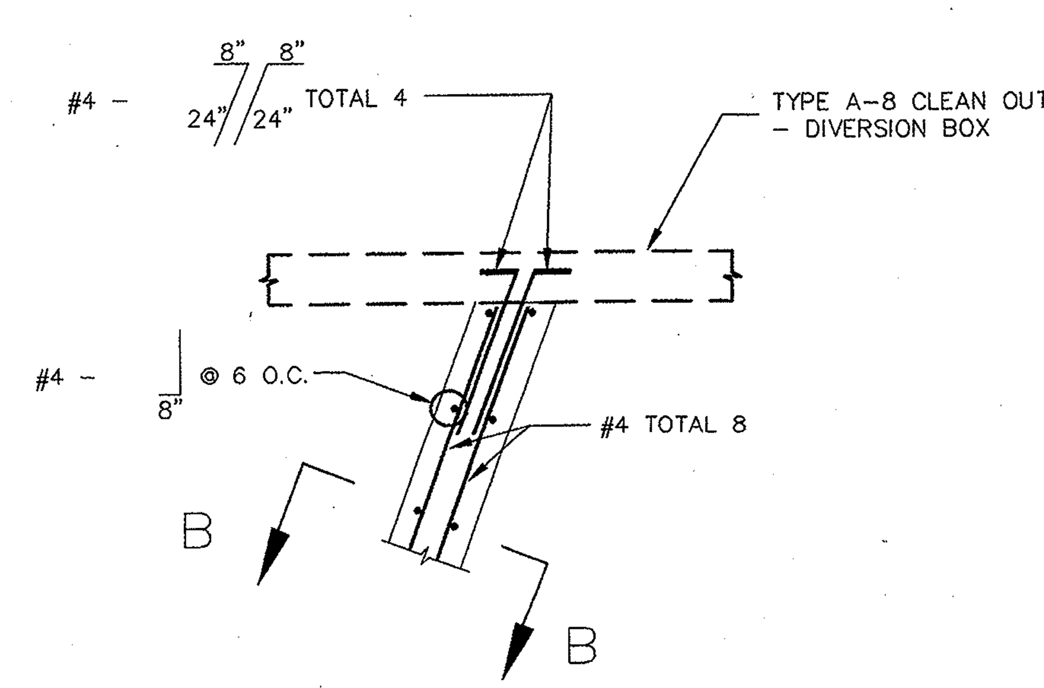




## LOW-FLOW RESTRICTOR PLATE (GALVANIZED STEEL PLATE)



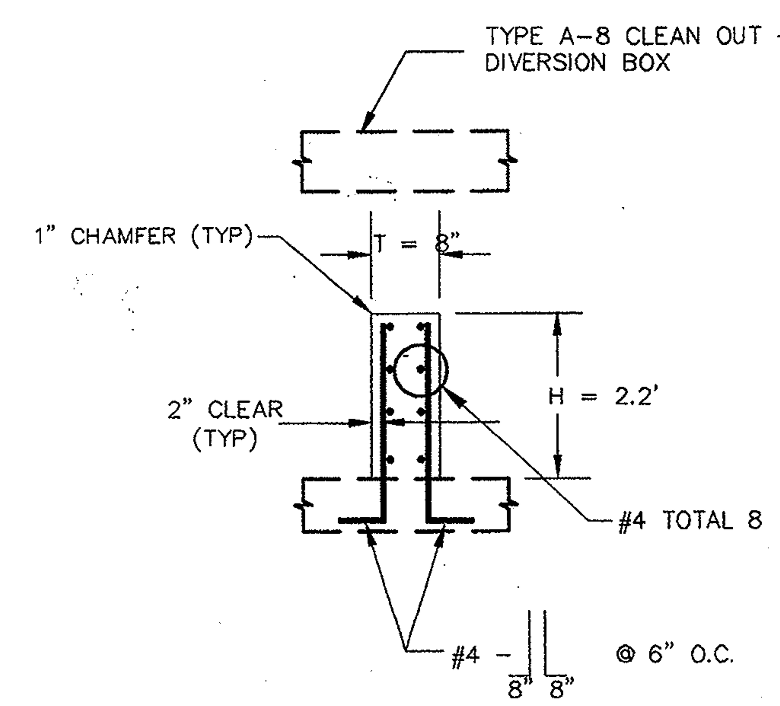

## TYPE A-8 CLEAN OUT - DIVERSION BOX DETAIL

(NO SCALE)




## DIVERSION WEIR DETAIL

(NO SCALE)




## SECTION B-B

(NO SCALE)


**COUNTY OF SAN DIEGO**
**DEPARTMENT OF PUBLIC WORKS**
**5555 OVERLAND AVENUE, SAN DIEGO, CA 92123-1295**

RICK ENGINEERING COMPANY 5620 FRIARS ROAD SAN DIEGO, CA 92110 619.291.0707 (FAX)619.291.4165 rickengineering.com
San Diego Riverside Sacramento Orange Phoenix Tucson

| REVISIONS | BY | APPROVED | DATE |
|---|---|---|---|
| 1 RECORD DRAWINGS | RLG | SML | 4-06 |

COORDINATE INDEX 350 N. 1683 E.
CONST. COMPL.
FIELD REVISIONS

UNDERGROUND DETENTION BASIN AT McCLELLAN-PALOMAR AIRPORT
In the Vicinity of Carlsbad
TYPICAL SECTIONS/ ABBREVIATIONS

SCALE: HOR. N/A VERT. N/A
W.A. – R.S. –
SHEET 2 OF 8


05/19/2006

FOR REDUCED PLANS
ORIGINAL SCALE IS IN INCHES

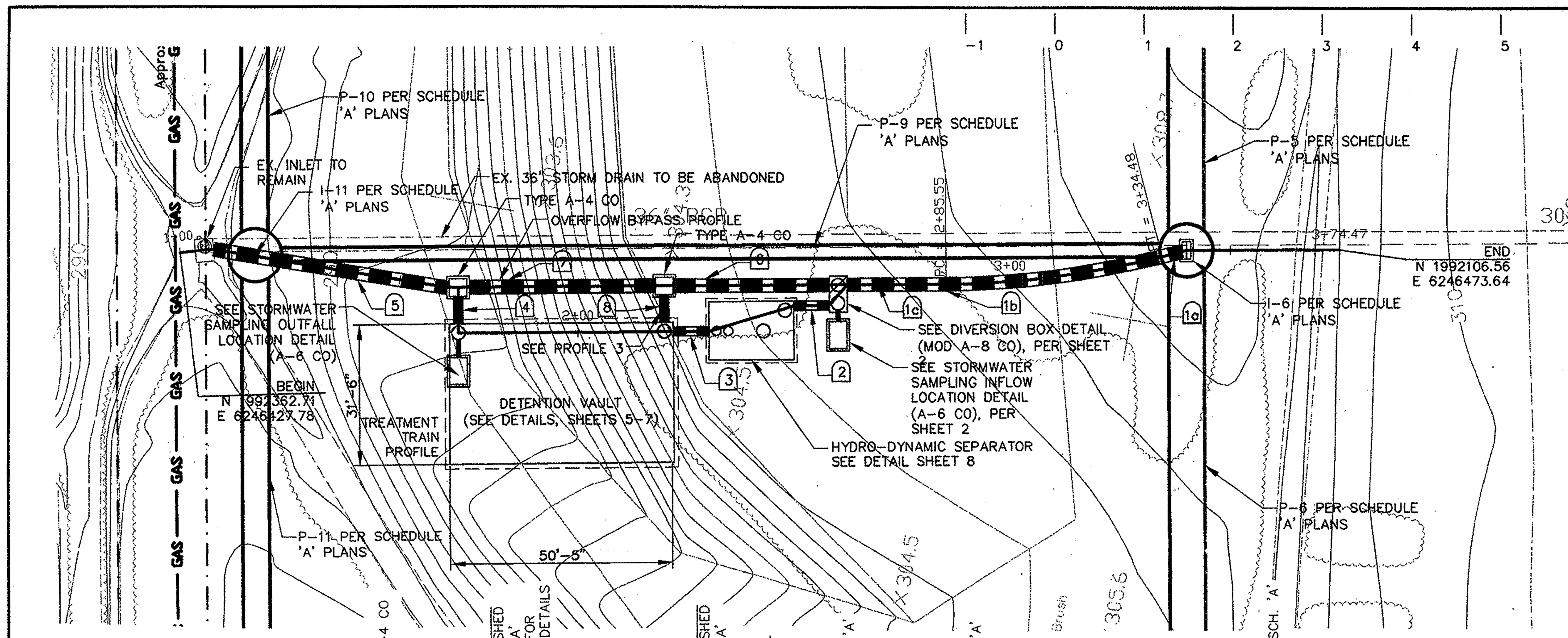
| PLANS | BY | DATE |
|---|---|---|
| DESIGNED | BRENDAN HASTIE | |
| CHECKED | CARL HEWINGS | |
| DELINEATED | | |

RICK ENGINEERING
5620 FRIARS RD.
SAN DIEGO, CA. 92110
619-291-0707

REGISTERED PROFESSIONAL ENGINEER · John D. Goddard, Jr. · No. 33037 · Exp. 6/30/06 · CIVIL · STATE OF CALIFORNIA

REGISTERED CIVIL ENGINEER 4-17-06 DATE

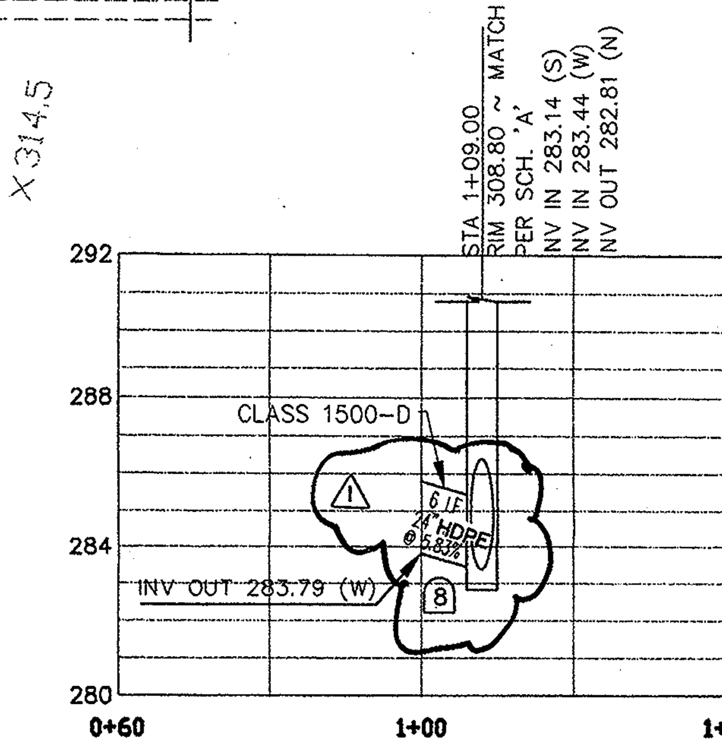
California Coordinate System Zone 6 NAD 83
Basis of Bearings



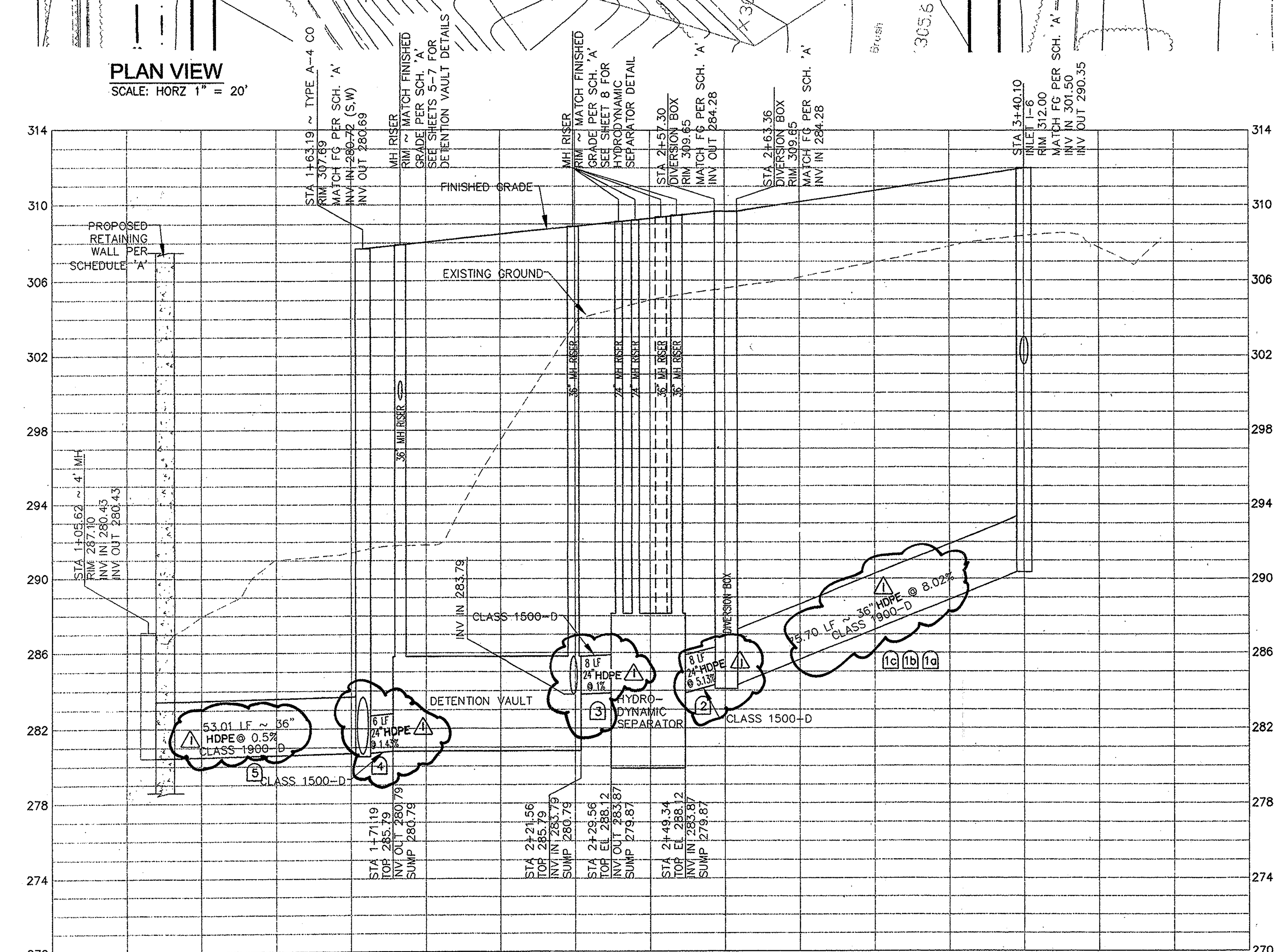

PLAN VIEW
SCALE: HORZ 1" = 20'

| NO. | DELTA OR BRG. | RADIUS | LENGTH | REMARKS |
|---|---|---|---|---|
| 1a | N24°26'10"W | | 4.59' | 36" RCP |
| 1b | Δ14°00'55" | 200.00' | 48.92' | 36" |
| 1c | N10°25'15"W | | 22.19' | 36" |
| 2 | N10°25'13"W | | 8.00' | 24" |
| 3 | N10°25'13"W | | 8.00' | 24" |
| 4 | N79°34'47"E | 53.01' | 6.00' | 24" |
| 5 | N00°32'22"W | | 53.01' | 36" |
| 6 | N10°25'13"W | 41.88' | 35.00' | 36" |
| 7 | N10°25'13"W | | 41.88' | 36" |
| 8 | N79°34'47"E | | 6.00' | 24" |

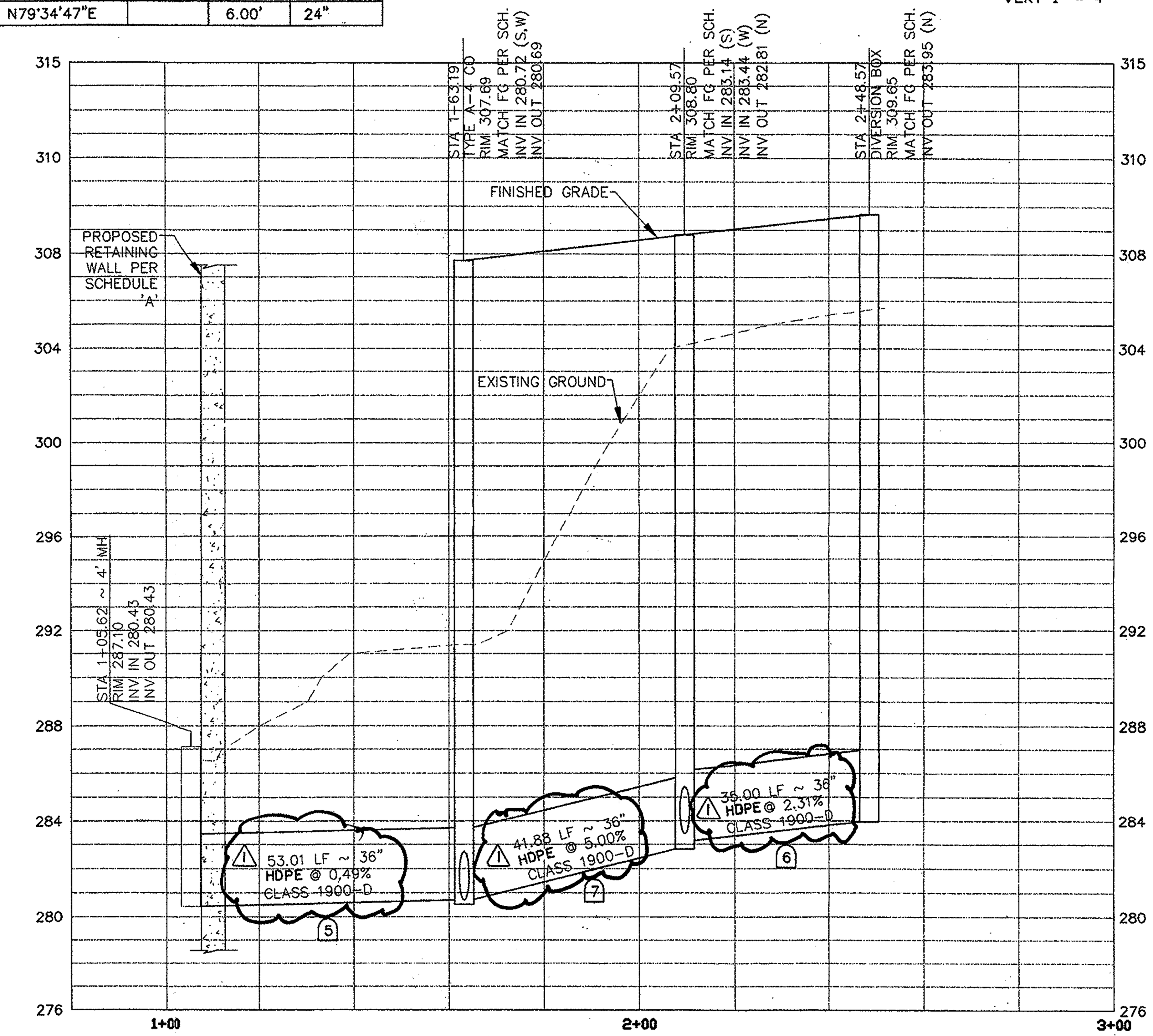
STORM DRAIN DATA




PROFILE 3
SCALE: HORZ 1" = 20'
VERT 1" = 4'




TREATMENT TRAIN PROFILE
SCALE: HORZ 1" = 20'
VERT 1" = 4'




OVERFLOW BYPASS PROFILE
SCALE: HORZ 1" = 20'
VERT 1" = 4'

**COUNTY OF SAN DIEGO**
**DEPARTMENT OF PUBLIC WORKS**
5555 OVERLAND AVENUE, SAN DIEGO, CA 92123-1295

RICK ENGINEERING COMPANY
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rickengineering.com
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| REVISIONS | BY | APPROVED | DATE |
|---|---|---|---|
| 1 RECORD DRAWINGS | RLG | SML | 4-06 |

COORDINATE INDEX 350 N. 1683 E.
CONST. COMPL.
FIELD REVISIONS

UNDERGROUND DETENTION BASIN AT McCLELLAN-PALOMAR AIRPORT
In the Vicinity of Carlsbad

PLAN & PROFILE

SCALE: HOR. 1"=20' VERT. 1"=4'
W.A. — R.S. —
SHEET 4 OF 8

05/19/2006